The Clinton of Western and Central New York

By

Tracy Gillette

A dissertation submitted to the Board of University Studies of the Johns Hopkins University in conformity with the the requirement for the degree of Doctor of Philosophy.

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THE CLINTON OF WESTERN AND CENTRAL NEW YORK

By

Tracy Gillette Ph. D.

Illinois State Geological Survey, Urbana, Ill.

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TRACY GILLETTE Ph.D., 1905–42

The talented author of this bulletin, Dr Tracy Gillette, died at his home, Urbana, Ill., November 9, 1942, after a brief illness. He had completed the manuscript for this bulletin several months before his death.

Doctor Gillette was a native of New York State. He had previously prepared for the New York State Museum Bulletin 320 on the Geology of Clyde and Sodus Bay quadrangles, covering his own home area.

THE CLINTON OF WESTERN AND CENTRAL NEW YORK

By

Tracy Gillette Ph. D.

Illinois State Geological Survey, Urbana, Ill.

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The writer wishes to acknowledge the hearty support given by the New York State Museum, the University of Rochester and The Johns Hopkins University. Originally the New York State Museum agreed to publish a geologic report and map on the Clyde and Sodus Bay quadrangles. The University of Rochester granted money for field expenses for the mapping and studying of these quadrangles. In the course of the investigation the writer became interested in the stratigraphy of the Clinton and the New York State Museum agreed to publish a report to cover the findings. The Johns Hopkins University agreed to accept the material as a subject for a doctor's dissertation.

The writer is indebted to many individuals, only a few of whom can be enumerated: Dr C. C. Adams, former Director of the New York State Museum, who made possible the publication of this report; C. A. Hartnagel, who not only accompanied the writer in the field and furnished many measured sections which are not now available but also aided in obtaining the diamond drill cores of the New York State Museum for study and furnished engineering data obtained at Lockport, New York, during the construction of the Barge canal in 1905 and 1906; Dr C. K. Swartz, whose helpful criticism has aided in the

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INTRODUCTION

Between the Niagara river and Willowvale, a small village southwest of Utica, the rocks of the Clinton group outcrop in a narrow band approximately two hundred miles long and between five and six miles wide in its broadest extent. The location and areal extent of the Clinton are shown on the accompanying map (figure 1, p. 7).

Except for a limited region in the immediate vicinity of Clinton, New York, where the strata outcrop in the highland to the south of the Mohawk river, the Clinton underlies the plains to the south of Lake Ontario and the low areas surrounding Oneida lake.

The surface of the lowlands bordering these lakes, is covered by a mantle of glacial material. Although this cover is not so thick as it is in some parts of New York State, it is exceptionally even in its distribution. The streams, due to low relief of these plains, have made very little progress in removing this cover. Only here and there where the larger creeks and rivers have succeeded in eroding and carrying away the products of the Pleistocene, and where the streams are not following the courses of some one of the numerous buried preglacial valleys, do the underlying rocks come to the surface.

The greatest single handicap to the stratigraphic geology of the Clinton is Oneida lake. Its waters cover practically the whole belt of Clinton outcrops for a distance of twenty miles and the swamps and alluvial deposits to the east and west of the lake cover about as much more.

Because of the features described in the preceding paragraphs, there are very few places where the entire Clinton can be studied. The best sections are found in the following places: in the Niagara gorge below the falls where it is entirely exposed; in the Genesee gorge at Rochester where there is equally good exposure; on Second and Salmon creeks in the town of Sodus where most of the rocks of this group are uncovered; in the vicinity of Fulton where it is possible by using many small outcrops to piece together a composite section; at Clinton where there are good outcrops of the Upper Clinton formations; and at Willowvale where a nearly complete section is obtainable. For the location of these points see figure 1, page 7.

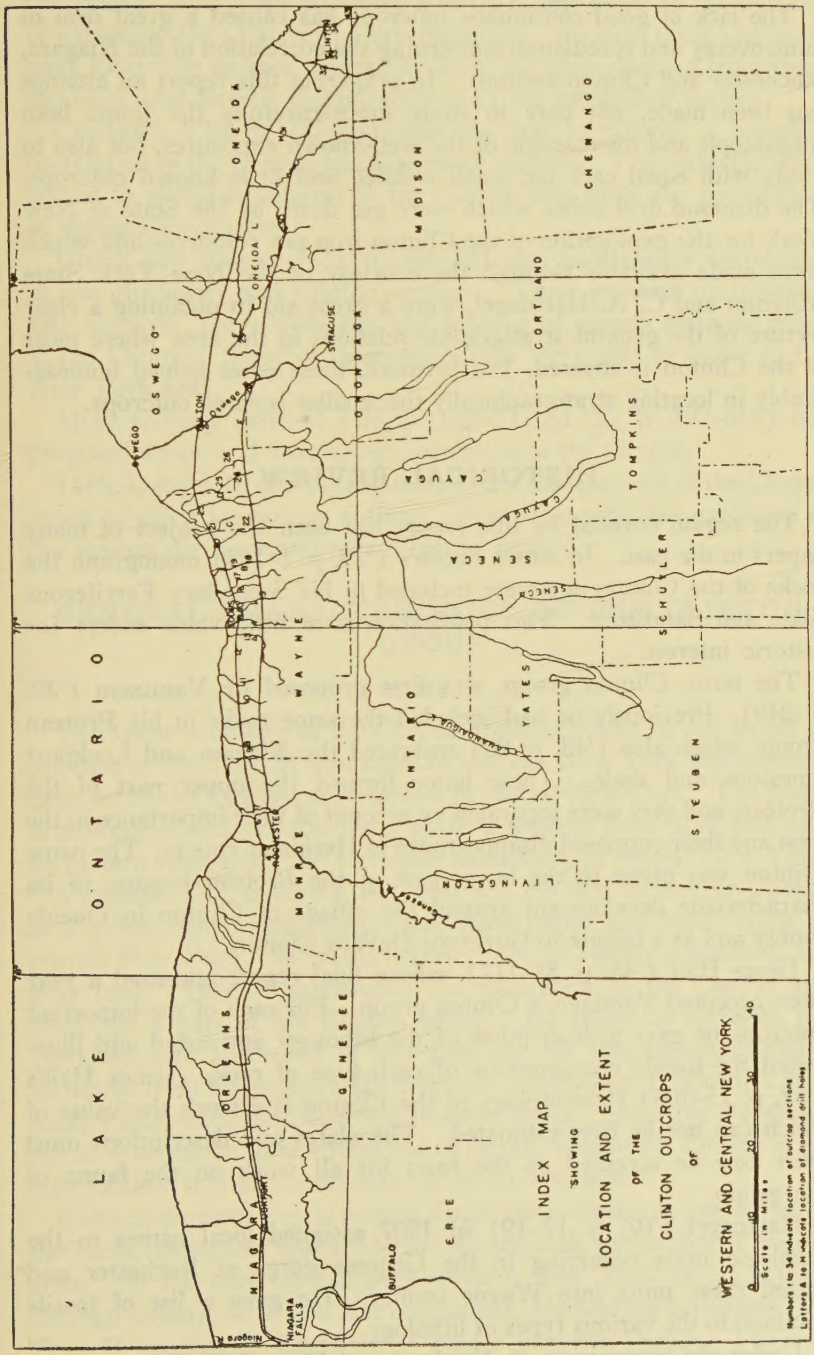

Figure 1 Map showing the location and extent of the Clinton outcrops of western and central New York

The lack of good continuous outcrops has caused a great deal of controversy and speculation concerning the correlation of the Niagara, Rochester and Clinton sections. In preparing this report an attempt has been made, not only to study more carefully the fauna both megascopic and microscopic of the well-known exposures, but also to study with equal care the small isolated and little known outcrops. The diamond drill cores, which were put down by the State of New York for the exploration of the Clinton iron ore resources and which were made available through the courtesy of the New York State Museum and C. A. Hartnagel, were a great aid in obtaining a clear picture of the general stratigraphic relations in the area where most of the Clinton is covered. Furthermore, these cores helped immeasurably in locating stratigraphically the smaller isolated outcrops.

HISTORICAL REVIEW

The region covered by this report has been the subject of many papers in the past. In Amos Eaton's ('29, p. 1–163) monograph the rocks of the Clinton age were included in his Secondary Ferriferous Slate and Sandstone. This publication is of little value except for historic interest.

The term, Clinton group, was first proposed by Vanuxem ('39, p. 249). Previously he had included the same rocks in his Protean group, which also ('42, p. 80) embraced the Niagara and Lockport limestone and shale. These latter formed the upper part of the Protean, and they were separated on account of their importance in the west and their supposed disappearance in Herkimer county. The name Clinton was given to the lower part of the Protean because of its characteristic development around the village of Clinton in Oneida county and as a tribute to Governor DeWitt Clinton.

James Hall ('43, p. 58–117), whose final report appeared a year later, accepted Vanuxem's Clinton group. For each of the important outcrops he gave a description of the lithology and listed and illustrated the fossils characteristic of each type of rock. James Hall's ('52, p. 15–105) Paleontology of the Clinton is a work the value of which can not be over-estimated. The plates and descriptions must even now be accepted as the basis for all work on the fauna of the group.

Hartnagel ('07, p. 12–19) in 1907 assigned local names to the lithologic units occurring in the Genesee gorge at Rochester and traced these units into Wayne county. He gave a list of fossils common to the various types of lithology.

Under the supervision of Newland and Hartnagel ('08, p. 1–76)

the State of New York put down a series of test holes for the purpose of exploring the Clinton iron ore resources. Because these test holes were located in an area covered by drift, the data obtained from them has been used directly or indirectly in all the succeeding papers.

Chadwick ('18, p. 327–68) was the first to attempt a complete correlation of the Clinton and Rochester sections. This valuable work served to stimulate interest in the Clinton and show the possibilities of detailed correlation.

Ulrich and Bassler ('23, p. 324–52) also published a correlation of the Rochester and Clinton sections. Their greatest contribution was, however, the establishing and defining of certain ostracod zones in the Clinton. Some of these zones they were able to locate in the New York area.

More recently Sanford ('35, p. 169–83 and '36, p. 797–814) has proposed a new and interesting correlation of the Clinton.

Table 1, pages 10 and 11, summarizes the classification of the Clinton strata as given by various authors. From this table the evolution of the various divisions and names can be seen.

GENERAL CHARACTERISTICS OF THE CLINTON GROUP

LIMITS

The lower boundary of the Clinton group is placed by the writer at the base of the Thorold sandstone in western New York and immediately below the Oneida conglomerate in central New York. The group is terminated with the Rochester shale in western New York and with its eastern equivalent, the Herkimer sandstone, in central New York.

Vanuxem ('42, p. 75–78, 80) who was the first to use the Clinton as a group name, established these same upper and lower limits in central New York. In western New York he rightly considered the gray band (Thorold sandstone) the equivalent of the Oneida and therefore a part of his Clinton group. He failed to correlate the Herkimer and Rochester of this area and for this reason excluded the latter from his group. He definitely established, however, a type locality and described the strata in some detail. Since the Rochester can now be shown to be equivalent to certain beds of his Clinton at its type locality, it would seem only logical to include it.

Quite aside from any historical usage the evidence as presented by the rocks themselves appears to harmonize with the proposed boundaries. At the base, spread over western New York as far east as Oswego county, is a thin but continuous, blanketlike formation, the Thorold sandstone. Eastward it grades into the Oneida. The two

TABLE 1

CLINTON NOMENCLATURE

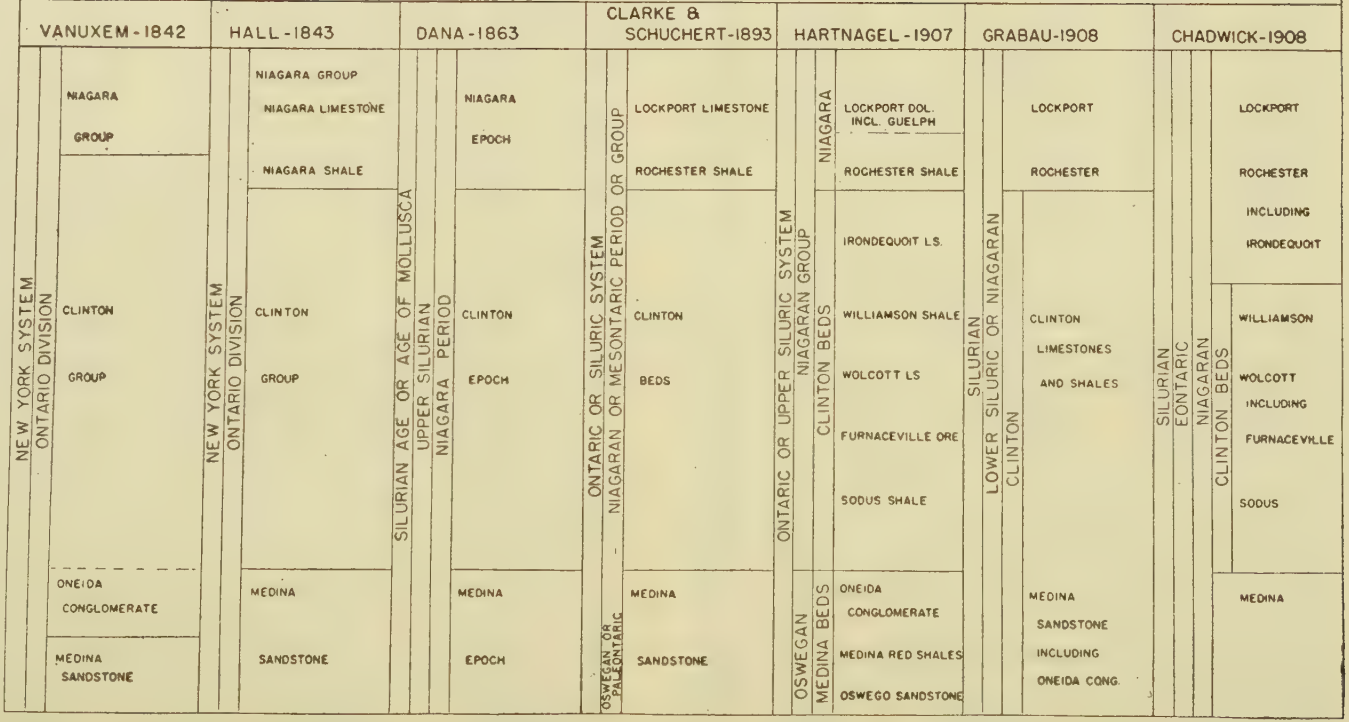

Table 1 Clinton nomenclature

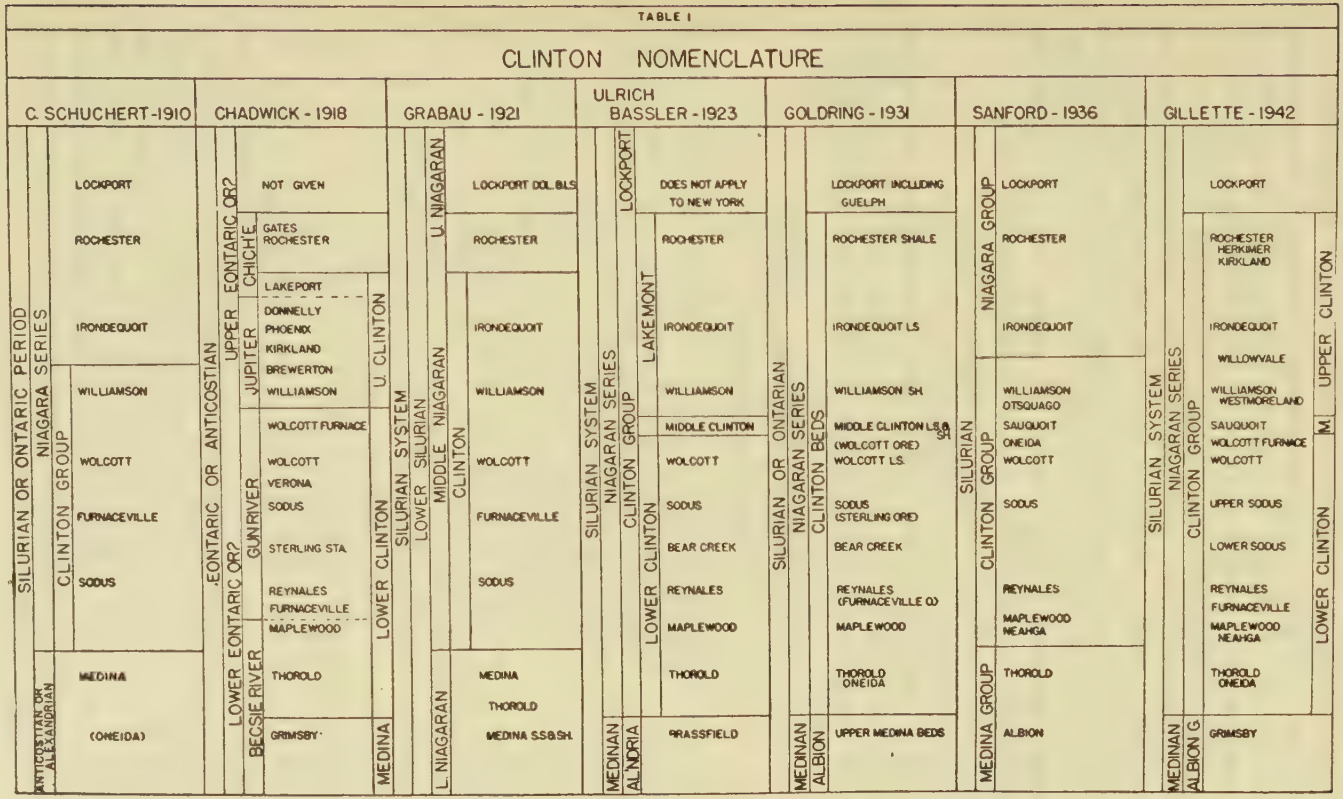

Table 1 Clinton nomenclature

formations appear to represent the initial deposits of the Clinton sea as it advanced over the semicontinental Grimsby of the underlying Albion group. Above the Thorold in western New York are alternating shales and limestones with thin iron ores. Above the Oneida is a succession of shales, silty shales and sandstones with similar iron ores. The sediments of the Clinton are everywhere marked by lateral and vertical variations. These variations can only be explained as the result of rapidly changing conditions under which the sediments were deposited. In contrast the overlying Lockport is composed of fairly uniform limestones and dolomites throughout its entire lateral and vertical extent. Such uniform sediments could only have formed under fairly widespread and stable marine conditions.

The boundaries of the Clinton have been the subject of much discussion in the past. Table 1, page 10 and 11, gives a brief summary of the views of various authors. A more complete review of this problem can be found in an earlier publication (Gillette, '40, p. 23, 24, 30–35).

SUBDIVISIONS OF THE CLINTON

General Divisions

On their distribution, faunal content and general characteristics, the rocks of the Clinton can be roughly divided into the Lower, Middle and Upper Clinton. The Lower Clinton is well-developed in western New York. In the area of outcrop its present maximum thickness is in Oswego county. The Middle Clinton occupies a relatively narrow area of outcrop in central New York. The maximum development of this part of the group is in the vicinity of Clinton. No trace of the Middle Clinton can be found west of eastern Wayne county. The Upper Clinton is present in outcrops both in central and western New York. It overlaps the strata of the Lower and Middle Clinton. It reaches its maximum thickness in the area of outcrop near the Cayuga and Wayne county lines (see figure 2, p. 13).

Similar divisions were recognized by Ulrich and Bassler ('23, p. 324-25), but they gave the Upper, Middle and Lower Clinton the rank of formations. This practice does not appear justifiable in New York State, particularly so if formations are used as strictly lithologic divisions. The Lower Clinton contains at least ten lithologic units which are distinct enough in themselves to be called formations, and which are certainly mapable units. The Upper, Middle and Lower Clinton are useful theoretical divisions based upon fossil assemblages and unconformities within the Clinton group and are in no way concerned with the lithology of the rocks.

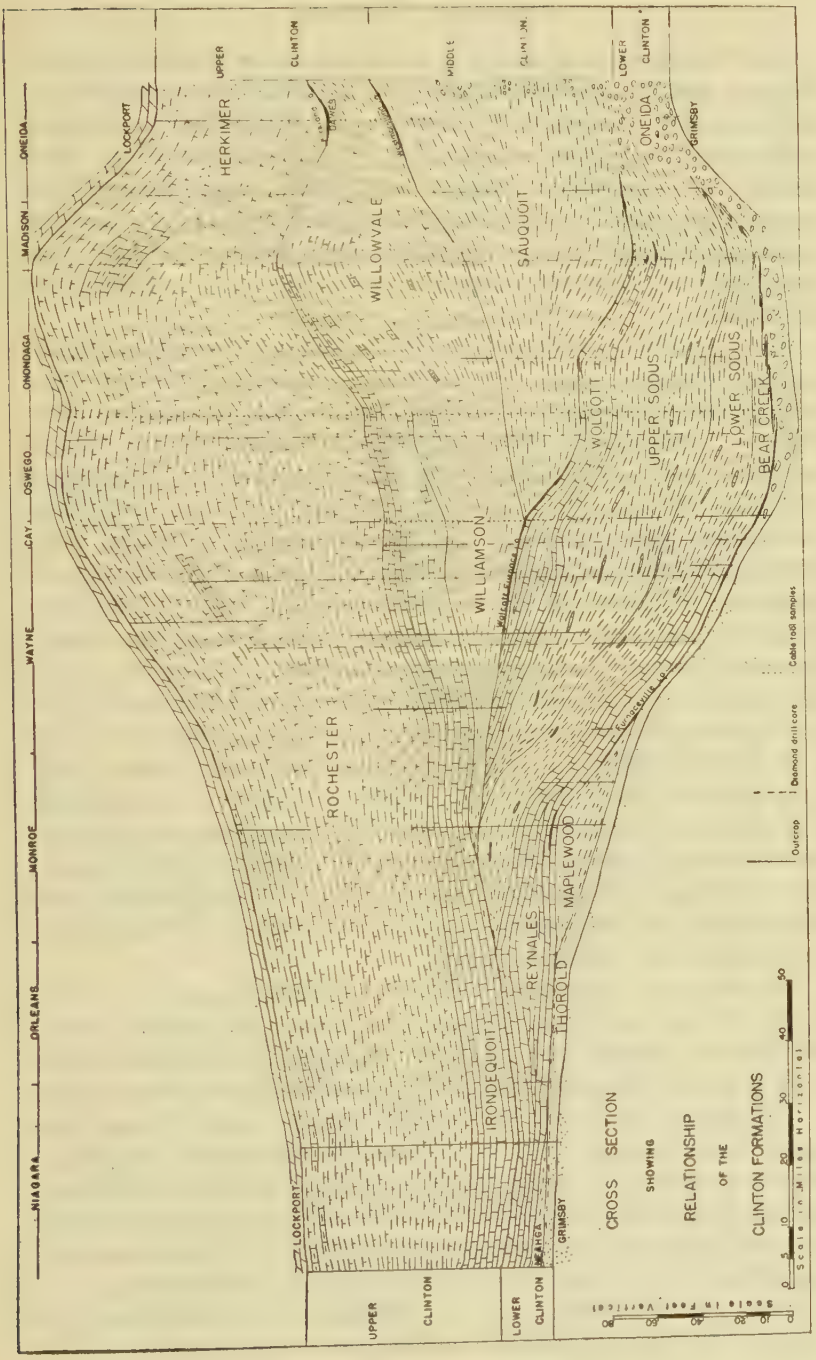

Figure 2 Cross section showing relationship of the Clinton formations.

Lithologic Divisions

The Clinton can be divided into formations on the basis of lithology. The only aim of such subdivisions is to establish easily recognizable and descriptive units which are based, so far as possible, on objective rather than interpretative reasoning. If characteristics other than lithology are allowed to govern the divisions, then interpretative reasoning must have the dominating role. The object of any geologic report is to interpret the geology of the region in terms of the formations. For this reason the formations themselves must be as objective as possible.

Most of the true lithologic units or formations have already been assigned adequate names. More than a hundred years ago Hall ('39, p. 290) designated the Upper Clinton shales of western New York as the Rochester. A few years later Vanuxem ('42, p. 75–78) introduced the term Oneida for the basal conglomerate. Hartnagel ('07, p. 12–17) named and assigned type localities to the Sodus, the Furnaceville, the Williamson and the Irondequoit. Grabau ('13, p. 460) correlated the gray band of Hall ('43, p. 34–57) with a certain sandstone in Ontario and gave it the designation, Thorold sandstone. Chadwick ('18, p. 327–66) in introducing the Maplewood, Bear Creek, Reynales, Wolcott Furnace, Sauquoit, Kirkland and Herkimer provided names for most of the remaining unnamed units. Sanford ('35, p. 169) added the term Neahga (see table 1, p. 10, 11). The writer ('40, p. 54–63) divided the Sodus into the Upper and Lower Sodus. Only three additional formation names appear necessary. It is suggested that the oolitic iron ore in the vicinity of Clinton village be called the Westmoreland, that the dark gray to green, calcareous shale immediately overlying the Westmoreland be termed the Willowvale, and that the light gray cross-bedded sandstone overlying the Willowvale be designated as the Dawes sandstone.

The recognized formations are listed in table 2, page 15. In the Niagara gorge three formations are accredited to the Lower Clinton, the Thorold, Neahga and Reynales. Eastward the Maplewood in Monroe county occupies a stratigraphic position similar to the Neahga of the Niagara area. The Furnaceville and the Lower Sodus shale appear in the section. In Wayne county the Maplewood disappears, but the Upper Sodus shale, the Wolcott limestone and the Wolcott Furnace iron ore are added. Eastward from Wayne county the Lower Clinton formations soon begin disappearing and in Oneida county all that remains of the Lower Clinton is the Oneida conglomerate.

In the Middle Clinton only two formations are recognized, the Sauquoit shale and the Oneida conglomerate. Only the upper portion

TABLE 2

CLINTON FORMATIONS

	NIAGARA COUNTY	MONROE COUNTY	WAYNE COUNTY	ONEIDA COUNTY
UPPER	ROCHESTER SHALE	ROCHESTER SHALE	ROCHESTER SHALE	HERKIMER SANDSTONE
				KIRKLAND IRON ORE
	IRONDEQUOIT LIMESTONE	IRONDEQUOIT LIMESTONE	IRONDEQUOIT LIMESTONE	WILLOWVALE SHALE
		WILLIAMSON SHALE	WILLIAMSON SHALE	
				WESTMORELAND IRON ORE
MIDDLE				SAUQUOIT SHALE
			WOLCOTT FURNACE IRON ORE	
LOWER			WOLCOTT LIMESTONE	ONEIDA CONGLOMERATE
			UPPER SODUS SHALE	
		LOWER SODUS SHALE	LOWER SODUS SHALE	
	REYNALES LIMESTONE	REYNALES LIMESTONE	REYNALES LIMESTONE	
		FURNACEVILLE IRON ORE	FURNACEVILLE IRON ORE	
	NEAHGA SHALE	MAPLEWOOD SHALE		
	THOROLD SANDSTONE	THOROLD SANDSTONE	THOROLD SANDSTONE	

Table 2 Clinton formations

of the Oneida conglomerate is Middle Clinton (see p. 15). The Middle Clinton does not outcrop west of Verona, Oneida county, but it can be traced by well logs as far as South Granby, Oswego county.

The Upper Clinton of Niagara county consists of two formations, the Rochester shale and the Irondequoit limestone. In Monroe county the Williamson shale appears at the base of the Irondequoit. These same formations continue eastward to Oneida county. In this region the Herkimer sandstone with the Kirkland iron ore at its base is seen occupying a position equivalent to the Rochester shale. The Willowvale shale has a stratigraphic position equivalent to the Irondequoit and part of the Williamson. The Westmoreland iron ore is situated at the base of the Upper Clinton in Oneida county.

Faunal Zones

Important divisions can be established in the Clinton on the fauna occurring in the rocks without regard to lithology. Such subdivisions based upon fossil evidence are called zones.

All fossil zones are considered to carry a certain time connotation. Under the most ideal conditions such zones would represent the rocks deposited within the life span of a single species or group of allied species. If time were the only factor in determining the presence or absence of fossils in the rocks, far more weight could be placed upon faunal zones. Evidence, however, points to the conclusion that other factors were involved in the present distribution of fossils. In the first place there is every reason to believe that ecology played a selective role in the past as in the present. Then also the sediments forming under varying conditions were not equally successful in preserving the evidences of past life.

That ecologic conditions did influence the organisms which lived in the Clinton seas can best be demonstrated by a few of the many examples. Take for instance the well-known brachiopod, *Pentamerus oblongus*. This form is found in two formations of the Lower Clinton, the Reynales and the Wolcott limestones. The fossils are not only confined to the separated formations (see table 2, p. 15), but they are even restricted to very definite portions within the formations themselves. In the Genesee gorge (section 5, p. 127) the Reynales has six layers containing *Pentamerus*. These are separated by rock containing no *Pentamerus*. In other sections (see section A, p. 175) the same alternation of *Pentamerus* with non-*Pentamerus*-bearing rock is observed. That the lateral extent of any one of those *Pentamerus*-bearing portions of either the Reynales or the Wolcott is not great is shown by the impossibility of tracing these horizons from outcrop to

outcrop. The sporadic occurrence of the *Pentamerus* certainly suggests strongly that they required a very special type of ecology and when, and only when, such living conditions existed did they flourish.

The brachiopod, *Bilobites biloba,* is another type whose present occurrence strongly suggests that either its very existence or at least its preservation must have been influenced by the conditions which were present in the Clinton seas. This odd-shaped fossil is not found except in calcareous, nonsilty, weak, crumbly shale layers. In such rock they are often abundant and if not alone, associated with very few other fossils. The *Bilobites*-bearing layers average less than two inches in thickness and never constitute the major portion of any given section. The very character of the shale suggests a unique condition of deposition. The distribution of *Bilobites* does not prove, however, that this form grew only under the conditions suitable to the deposition of these shales. The shells of this fossil are delicate and extremely fragile, and it is possible that the shale represents the only type of lithology in which they could be easily preserved. Whether the occurrence is due to a suitable environment or to the lack of preservation, the range of any fossil having such rigid requirements is of questionable value in determining the age or in correlating formations.

The present-known distribution of the trilobite, *Dalmanites limulurus,* shows the fallacy of placing too much emphasis on the range of any given species. Because the section around Rochester has been studied more carefully than any other section of the Clinton in the State, this fossil has been considered by many as a guide fossil for the Rochester shale. It is true that the fossil appears to be confined to the Rochester, but this can be explained by the type of rock present in that area. In the Genesee gorge the Rochester shale is underlain by a crystalline, crinoidal limestone, the Irondequoit, and that in turn by the graptolite-bearing shales of the Williamson. Neither of these appear to have been formed in environments which were favorable to the growth and preservation of *D. limulurus.* To the east of Monroe county, the conditions of sedimentation were different and *D. limulurus* is found throughout the whole thickness of the Upper Clinton. Furthermore, the careful collection and study of a large number of species failed to show any difference whatsoever between those specimens collected from the Rochester and the ones found in the underlying formations.

The faunal tables (table 3, p. 18–21) point to the conclusion that the common ostracods are better suited for the purpose of zoning than any other class of organisms. They have a short vertical range. They occur in such numbers in the rocks that the presence or absence of a given group can be easily checked. They are found in shales, lime-

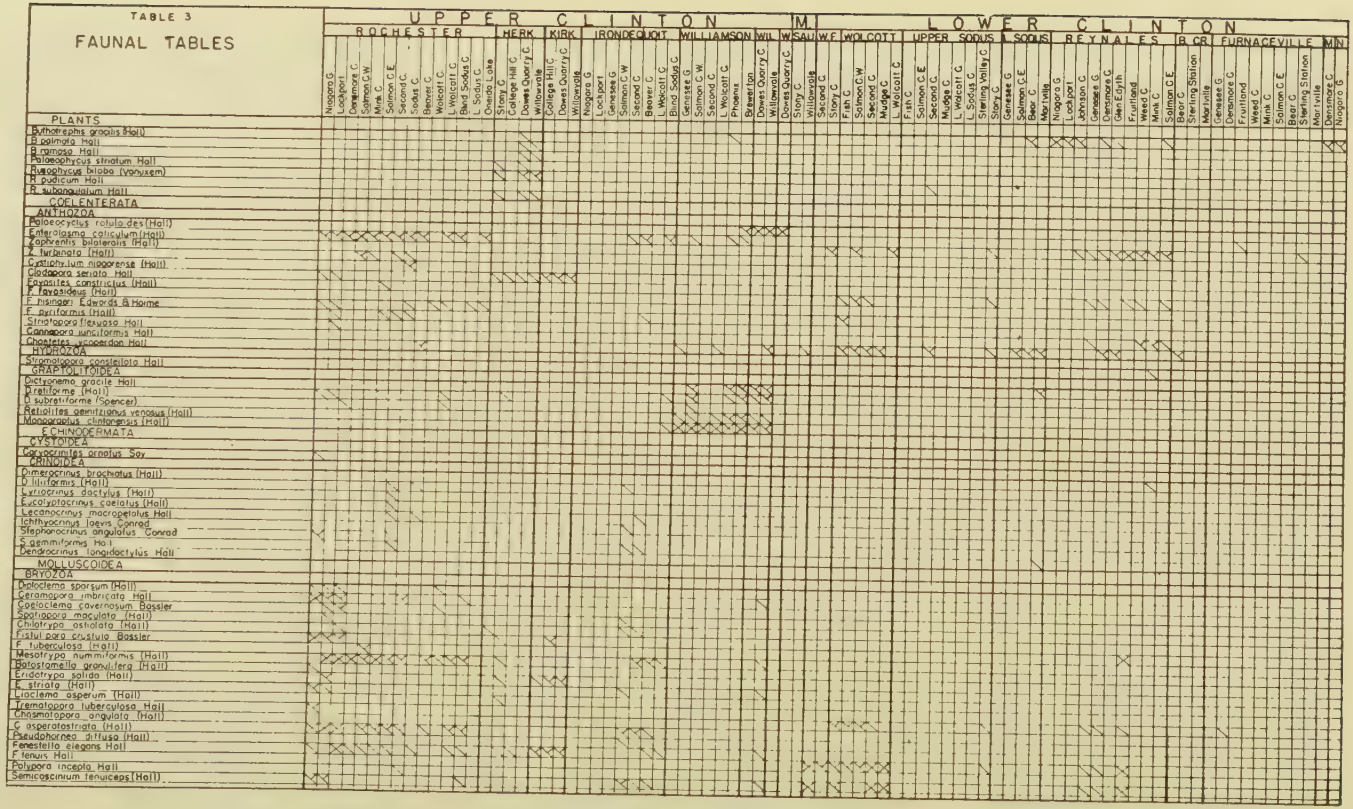

Table 3 Faunal tables

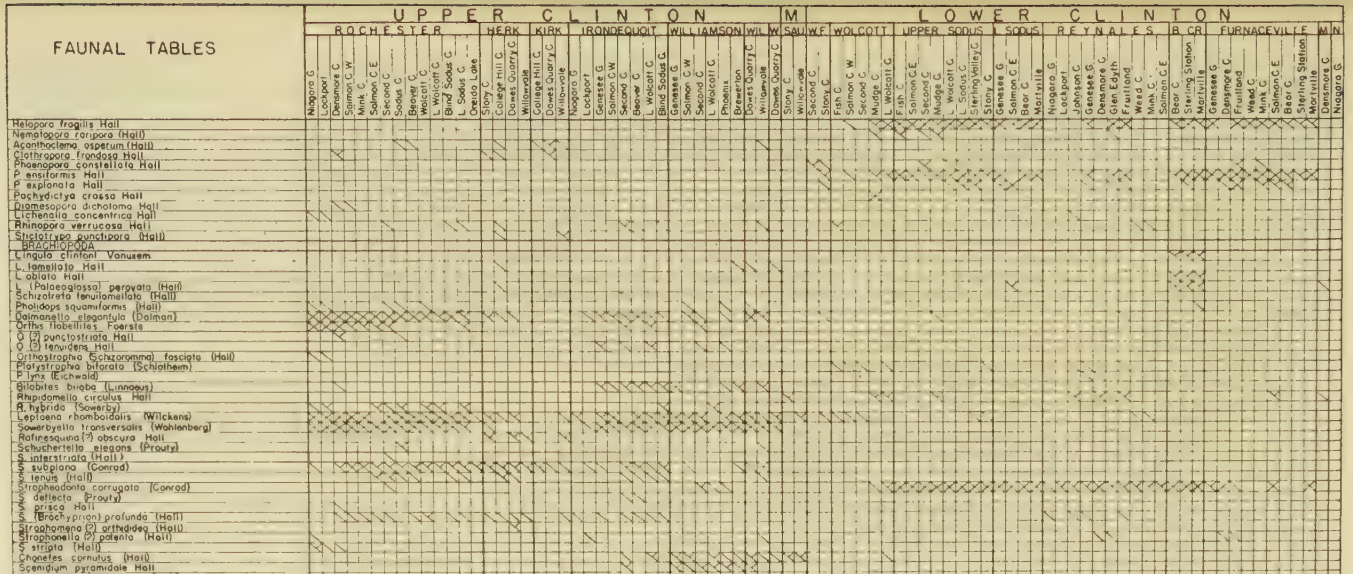

Table 3 Faunal tables

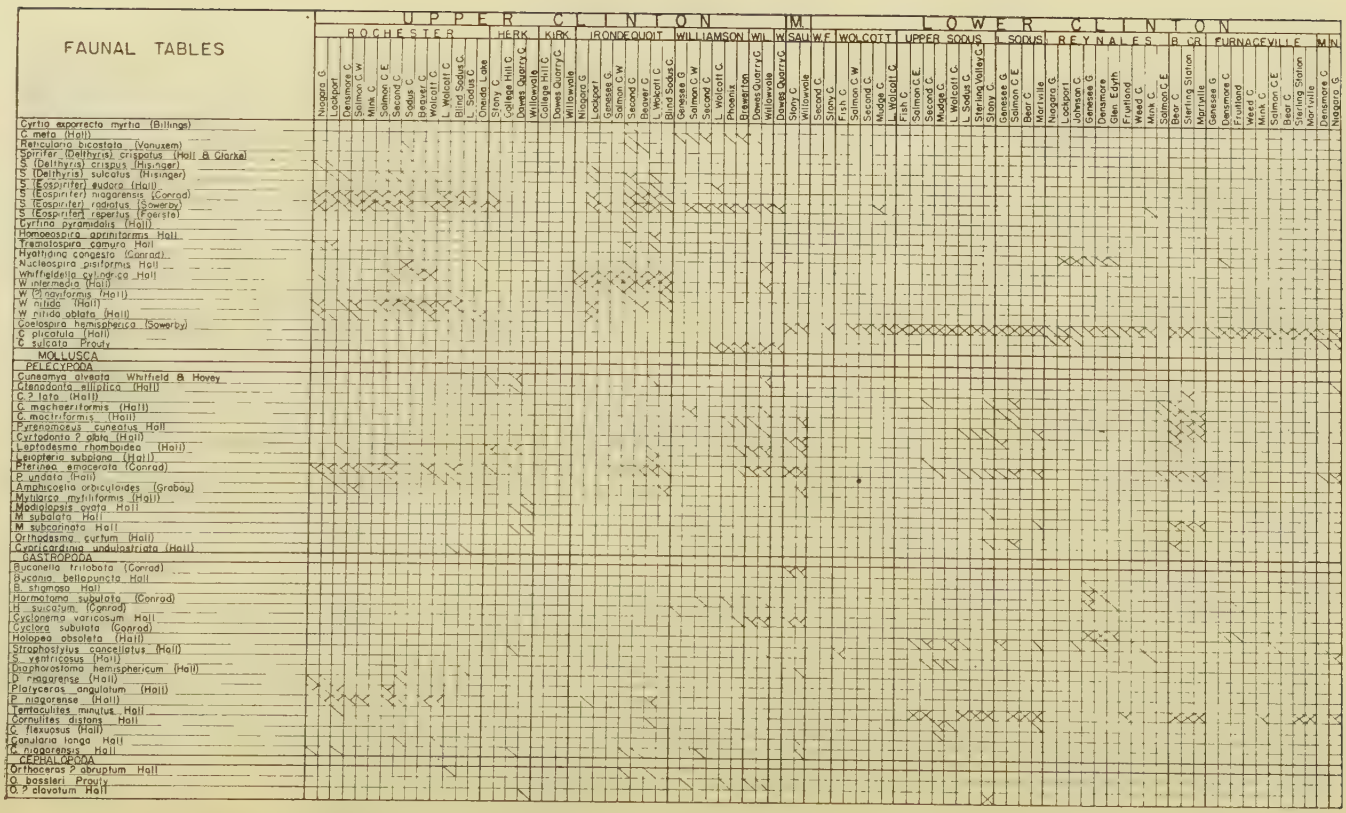

Table 3 Faunal tables

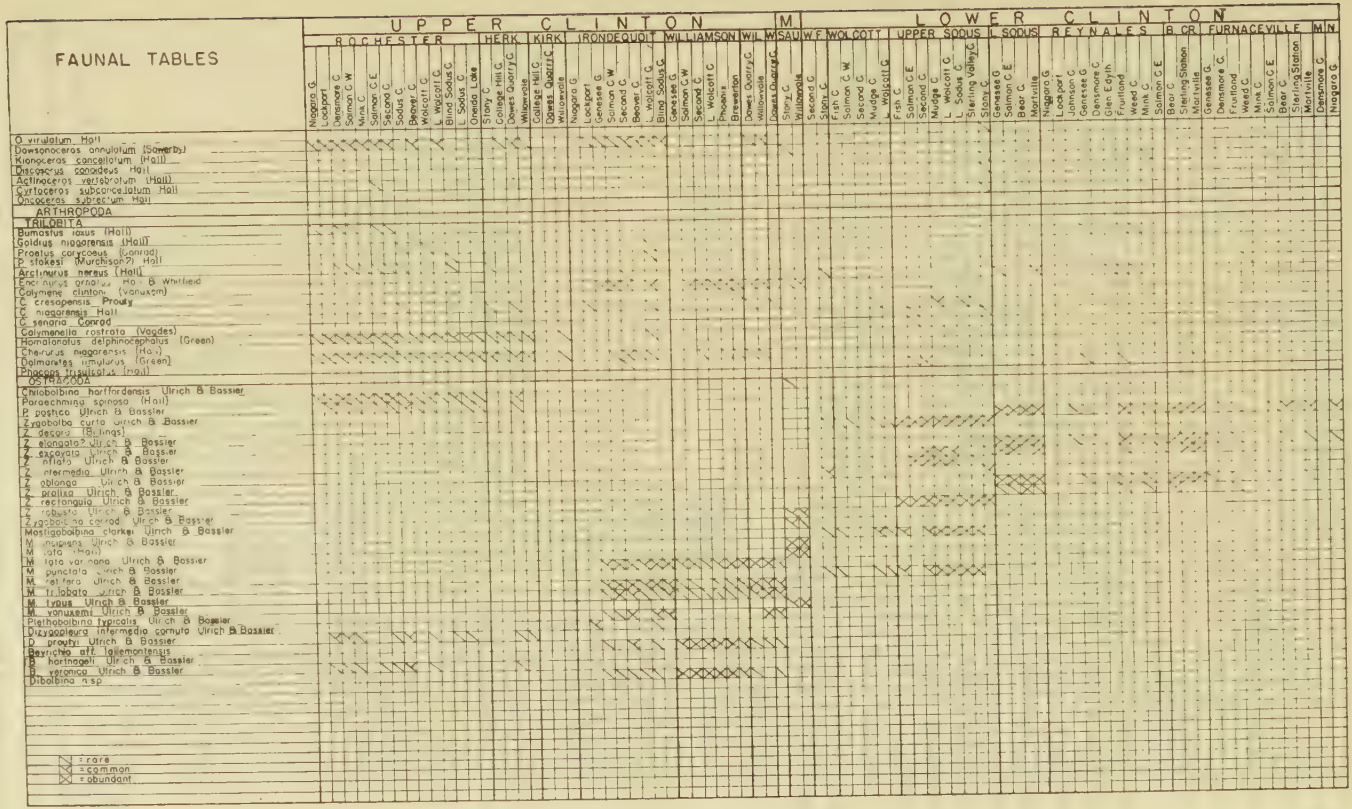

Table 3 Faunal tables

stones, sandstones and iron ores and thus seem to have been able to live and be preserved under a greater variety of conditions than any other class of organisms living in the Clinton seas. In fact there are only three formations, the Thorold and the Maplewood of western New York and the thin cross-bedded Dawes sandstone at Clinton (section 33, p. 169), which have not yielded ostracods. If they are not in the limestone layers, they will be in the thin shale breaks between the layers. If they are not in one type of shale, they will be in an adjacent shale of slightly different character. A thorough search never fails to reveal them. In the limestone layers the original shells are often preserved. In the shale layers they usually are present as natural internal casts. In the weathered sandstones they are most often represented as external molds. The only handicap ostracods have is their small size which makes them difficult if not impossible to accurately determine in the field.

Five ostracod zones can be recognized in the Clinton of New York State, two each in the Upper and Lower Clinton and a single zone in the Middle Clinton. These zones are:

Upper Clinton
- *Paraechmina spinosa* zone
- *Mastigobolbina typus* zone

Middle Clinton
- *Mastigobolbina lata* zone

Lower Clinton
- *Zygobolba decora* zone
- *Zygobolba excavata* zone

Ulrich and Bassler ('23, p. 349–52, 372–91) were the first to suggest using ostracods as a basis for correlating and subdividing the Clinton. They recognized the following zones:

Upper Clinton
- 9 *Drepanellina clarki* zone
- 8 *Mastigobolbina typus* zone
- 7 *Bonnemaia rudis* zone

Middle Clinton
- 6 *Zygosella postica* zone
- 5 *Mastigobolbina lata* zone
- 4 *Zygobolbina emaciata* zone

Lower Clinton
- 3 *Zygobolba decora* zone
- 2 *Zygobolba anticostiensis* zone
- 1 *Zygobolba erecta* zone

The *M. typus, M. lata* and *Z. decora* zones of this publication correspond exactly to the zones which Ulrich and Bassler recognized not only in New York but in Anticosti, Pennsylvania, Maryland and other states in the Appalachian Valley region. The *Z. excavata* zone

TABLE 4

CLINTON OSTRACOD ZONES

	NIAGARA COUNTY	MONROE COUNTY	WAYNE COUNTY	ONEIDA COUNTY
UPPER	PARAECHMINA SPINOSA ZONE — ROCHESTER	PARAECHMINA SPINOSA ZONE — ROCHESTER	PARAECHMINA SPINOSA ZONE — ROCHESTER	PARAECHMINA SPINOSA ZONE — HERKIMER / KIRKLAND
	MASTIGOBOLBINA TYPUS ZONE — IRONDEQUOIT	MASTIGOBOLBINA TYPUS ZONE — IRONDEQUOIT / WILLIAMSON	MASTIGOBOLBINA TYPUS ZONE — IRONDEQUOIT / WILLIAMSON	MASTIGOBOLBINA TYPUS ZONE — WILLOWVALE / WESTMORELAND
MIDDLE				MASTIGOBOLBINA LATA ZONE — SAUQUOIT / ONEIDA
LOWER			ZYGOBOLBA DECORA ZONE — WOLCOTT / UPPER SODUS	ZYGOBOLBA DECORA ZONE — ONEIDA
	ZYGOBOLBA EXCAVATA ZONE — REYNALES / NEAHGA	ZYGOBOLBA EXCAVATA ZONE — LOWER SODUS / REYNALES / FURNACEVILLE	ZYGOBOLBA EXCAVATA ZONE — LOWER SODUS / REYNALES / FURNACEVILLE	

Table 4 Clinton ostracod zones

probably corresponds to their *Z. anticostiensis* zone. Most of the forms which are associated with *Z. anticostiensis* in Maryland and Anticosti have been found in New York, but *Z. anticostiensis* itself has not been identified from this State. To avoid any possible misunderstanding and confusion the zone is designated as *Z. excavata.* In a similar manner the forms allied with *Drepanellina clarki* in Pennsylvania and Maryland (F. M. Swartz, '34, p. 81–134 and '35, p. 1165–194) are found in New York State, but *D. clarki* itself has never been collected or identified from this area. For this reason the zone is therefore called *Paraechmina spinosa.*

In table 4, page 23 the occurrence of the five ostracod zones in Niagara, Monroe, Wayne and Oneida counties is summarized. The table also shows the formations in which ostracods are known to occur. The details concerning the presence of ostracods will be discussed later in connection with each separate formation.

DETAILED STRATIGRAPHIC AND PALEONTOLOGIC RELATIONS

LOWER CLINTON

Thorold Sandstone

Definition. The Thorold quartzite (gray band of earlier reports, see p. 9) was named from an exposure at Thorold, Ontario (Grabau, '13, p. 460). At the type locality the formation is a quartzite (see Williams, '19, p. 25) but everywhere in New York and in most places in Ontario it is a sandstone. Consequently the formation has become more fittingly designated as the Thorold sandstone.

Extent and lithologic characteristics. The Thorold in the Niagara gorge is a light gray, fine-grained resistant sandstone. Its resistant character makes it stand out as an easily recognizable unit. The formation is six feet thick. The upper three and one-half to four feet is a single massive bed. The lower part is thin-bedded and in places cross-bedded. The sandstone is very fine grained. The individual quartz grains range from silt to very fine sand according to the Wentworth scale. The sand grains are not well-rounded and range from angular to semiangular. The formation is highly but not uniformly argillaceous throughout, the upper massive portion appearing to be more argillaceous than the underlying thinner cross-bedded part. At Niagara the argillaceous material is confined to the matrix of the sandstone layer. Only two or three thin shale breaks were observed between the sandstone layers. The cementing material is both siliceous and calcareous with silica having the dominating

Figure 3 Genesee gorge. Note gray resistant Thorold which overlies the red Grimsby sandstone and underlies the green Maplewood shale

role. The small grain size, the angularity, the argillaceous content and the degree of cementing have all contributed to produce a dense, compact sandstone. Even weathered samples show little porosity and less permeability.

Microscopic analysis of the Thorold by Alling ('36, p. 196) shows the Thorold to consist of 70 per cent quartz, 6 per cent feldspar and 20 per cent argillaceous material. The argillaceous material includes "chlorite, muscovite, rusty biotite and uralite." The accessory minerals make up about 4 per cent of the rock. They include according to Alling "grains of calcite, calcite as a cement, opaline silica, ilmenite with attendant leucoxene, chromite, garnet, magnetite, zircon, apatite and tourmaline." Sanford's ('39, p. 77–85) mechanical analysis and insoluble residue studies show the calcareous content of the rock to be approximately 1 per cent.

To the east of the Niagara gorge the Thorold can be traced through the Lockport and Gasport outcrops to the Genesee gorge (figure 3). For a sandstone there is surprisingly little variation in thickness, being six feet at Lockport, six and one-half feet north of Gasport and five feet in the Genesee gorge. At Lockport the massive character of the Thorold of the Niagara gorge is retained. A single layer was observed measuring over three feet in thickness. From Lockport eastward the formation is better stratified and there is very little cross-bedding. As the layers become thinner and more abundant, green silty shales are found separating the thicker sandstone layers. As a whole the formation retains its dense, compact character which together with its light gray color sets it off from the underlying Grimsby. It possesses the same resistance to erosion which explains its position as cap rock for the lower falls of the Genesee river.

A study of the microlithology of the Thorold between the Niagara gorge and Rochester reveals that the only appreciable change that has taken place is in the thin shale breaks, mentioned in the foregoing paragraph. As far east as Lockport fine silty quartz is the dominant constituent of the shale layers with the argillaceous material forming less than 50 per cent of the rock. To the east in Monroe county true argillaceous shales are more abundant. Even in the Genesee gorge the shale breaks, however, contain a high percentage of quartz. It seems, as Alling ('36, p. 192) has pointed out, that the development of shaly structure can be caused by a surprisingly small amount of clay minerals.

The Thorold can be traced with no great difficulty eastward from the Genesee gorge to western Cayuga county. This is largely due to the fact that the formation retains its characteristic light gray color and its fine angular quartz groundmass. The formation ranges from

less than four feet to six feet. The argillaceous content of the sandstone layers increases. Furthermore true argillaceous green shales are common and some attain a thickness of two inches. In addition flattened green clay pellets are seen embedded in the sandstone layers. These pellets, which are discussed at some length in a previous publication (Gillette, '40, p. 40–43), are always either parallel or nearly parallel to the bedding planes. The sandstone becomes more calcareous, and with the increase in calcium carbonate it is less resistant and more friable. In Wayne county the contact of the Grimsby and the Thorold is not so sharp as it is to the west and in places the two are actually seen grading into each other.

There is considerable change in the Thorold sandstone in crossing the relatively narrow northern part of Cayuga county. In western Cayuga county the Thorold is approximately five and one-half feet thick. In extreme eastern Oswego county at Lunn's quarry between Martville and Hannibal, only four miles distant in a direct line, the formation increases to seven and one-half feet. The upper two and one-half feet is coarser than the Thorold of western New York and ranges according to the Wentworth scale from fine to medium. It contains dark gray, phosphatic sandstones interbedded with the typical light gray layers. Immediately underlying this portion is a conglomerate which varies from less than an inch to more than six inches in thickness. The conglomerate contains pebbles up to a centimeter in diameter. The remaining portion of the Thorold consists of fine-grained silty sandstone which is similar to the Thorold of western Cayuga and Wayne counties.

The contact of the Thorold with the underlying Grimsby is gradational and in this respect also is like the Thorold of western Cayuga and Wayne counties. The upper contact however is quite different. To the west the overlying formations usually show an increase in the amount of sand as the contact is approached, but there is no interbedding of sandstone with the overlying shales, limestones or iron ores. At Lunn's quarry there is a very definite thin transition zone in which shales and stringers of iron ore are found interbedded with sandstones. The sandstones are similar to the underlying Thorold in color and composition. The dark gray to green shales are like the overlying Bear Creek in lithology and fossil content.

The next outcrop is located only about six miles east at Fulton. The rocks occupying the stratigraphic position of the Thorold, are conglomeratic and are considered the westernmost outcrop of the Oneida conglomerate.

Fauna. For the most part the Thorold contains very few fossils. *Arthrophycus alleghaniensis* is by far the most common fossil and is

best seen in the weathered sandstones. At Lunn's quarry near Martville (section 25) the shales interbedded with sandstones in the transition zone contain fossils common or restricted to the *Zygobolba excavata* zone of the Lower Clinton. The most common forms are the brachiopods, *Lingula clintoni* and *L. perovata* and the ostracods, *Zygobolba prolixa* and *Z. curta.*

Age and origin. There has been considerable discussion concerning the age of the Thorold sandstone. Many geologists (table 1, p. 10 and 11) have considered it as Albion in age. Others have thought it more closely related with the overlying Clinton. The writer subscribes to this latter view. The finding of definite Clinton ostracods in the Thorold of Lunn's quarry (section 25, p. 160) and the lateral gradation of the Thorold into the Oneida conglomerate which also yields a Clinton fauna would seem to make this formation Clinton beyond reasonable doubt.

The Thorold was evidently laid down as the initial deposit in the Lower Clinton sea whose marine waters spread out and covered the low geosynclinal area of which western New York was a part. The fine character of the sediments is evidence that this formation was deposited far from any high land mass or source of coarse clastics. Alling ('36, p. 196) has given some petrographic evidence pointing to the conclusion that the Thorold may have been derived from the underlying Grimsby. The lack of any definite line of separation between the Thorold and the Grimsby in some areas (p. 28) is in agreement with this contention. It is reasonable to expect that the sea would rework the upper layers of the underlying recently deposited sandstones of the preceding Albion group.

The similarity in the character of the sediments of the Thorold and the Grimsby may be due on the other hand to the fact that these two formations derived their clastics from the same source. Proof exists that a high land mass lay to the east in both Albion and Lower Clinton times (p. 34). The fact that the Oneida interfingers with the Thorold would tend to show that some of the finer clastics must have been carried into the sea along with the coarser material.

In summary it seems likely that the Thorold formed from eroding, reworking and a redeposition of the previously formed Grimsby with the addition of some fresh clastic material from the east. The reworking could not have taken place *in situ* since in many places the formation is thin-bedded with relatively thick and undisturbed shale partings. The amount of new clastics added was probably very significant east of Wayne county but was of little importance to the west.

Oneida Conglomerate

Definition. The Oneida conglomerate was named by Vanuxem ('42, p. 75) "from well-defined exposures in Oneida county." This formation and the Rochester shale bear the distinction of being the only two subdivisions of the Clinton group which were named and established as distinct units by the first New York State Geological Survey and which are still used.

Extent and lithologic characteristics. The westernmost outcrop of the Oneida conglomerate is on Oswego river at Fulton. It is located only eleven miles east of the Thorold outcrop near Martville, but in this distance the Thorold has changed to the Oneida and the basal deposit of the Clinton has almost doubled its thickness, and measures about 12 feet. The massive conglomerates typical of the Oneida are interbedded with light gray sandstones. Most of the conglomerates are tightly cemented with silica. The cementation is so complete and thorough that the rock breaks across the pebbles rather than around them. One of these resistant conglomerates forms the cap rock for the falls at Fulton. Most of the sandstone layers are coarser than the Thorold of western New York. One layer three feet from the base, however, showed sand ranging from fine to very fine and also contained clay pellets like those observed in western Cayuga county.

The upper contact of the Oneida conglomerate with the overlying formations is not exposed. The basal contact with the Grimsby is sharp and because of the cross-bedded nature of the upper layers of the Grimsby at Fulton it is spectacular (see figure 4, p. 31).

Between Fulton and Oneida lake there are few outcrops of this formation but east of the lake in the town of Verona there are a number of good exposures. In this area the Oneida consists of white to light gray conglomerates with interbedded coarse sandstone. The typical conglomeratic layers are made up of poorly sorted material usually varying from coarse sand to pebbles a half inch in diameter. The largest pebble found measured two and one-quarter inches in diameter. Both the pebbles and the coarse sand are well-rounded. The cementing matrix is silica and the cementation has been so complete through the introduction of this secondary silica that there is very little porosity. These very resistant conglomeratic layers are often found as ledges in the fields and form small escarpments which can be traced for a considerable distance. The top of some of the massive layers shows glacial polish and striae. The sandstone layers, like the conglomeratic, are poorly sorted. The grains vary from coarse to fine. The coarse grains are more abundant than the fine.

Figure 4 Fulton, New York. Contact of Oneida and Grimsby

Figure 5 Quarry in the Oneida conglomerate east of Willowvale

The process of cementation was not so complete in these layers as in the conglomerate. Some outcrop specimens are even friable and show a much higher degree of porosity than in either the Thorold of western New York or the conglomeratic layers of the Oneida in central New York. They are less resistant. Shale layers are almost entirely lacking in the lower part of the Oneida conglomerate, but in the upper third and particularly near the contact with the overlying Upper Sodus thin, silty shales are abundant.

The Oneida conglomerate continues east beyond the limits covered by this report. It attains a maximum known thickness of about 30 feet near Willowvale (figure 5). Others have reported as much as 70 feet but the writer could find no such thickness. In the area east of Oneida lake the Oneida retains the same lithologic characteristics.

The exact contact of the Oneida with the underlying formation is not exposed east of Fulton within the area covered by this report. Vanuxem ('42, p. 75–78) and more recently Hartnagel ('07, p. 27–37) have shown that the Oneida overlaps increasingly older formations to the east. The upper contact of the Oneida is gradational. At Verona it interfingers with the Upper Sodus shale. At Willowvale the upper layers are interbedded with shale similar to the Sauquoit in lithology and fossil content. At Verona the transition zone is estimated to be about five feet thick. At Willowvale (section 34, p. 171) conglomeratic layers are found more than 20 feet above the massive Oneida.

Fauna. The conglomeratic layers of the Oneida rarely contain *Arthrophycus alleghaniensis.* It is more common in the sandstone layers. This fossil is particularly abundant at Verona and at Fulton. The thin, silty shales of the upper part of the Oneida yield some fossils. At Verona (section 31, p. 164) they contain fossils restricted or common to the *Zygobolba decora* zone of the Lower Clinton. The brachiopods, *Coelospira hemispherica* and *Stropheodonta corrugata,* and the ostracod, *Z. decora,* are the most characteristic fossils. At Willowvale (section 34, p. 171) these shales are rich in pelecypods and contain many trilobites, particularly *Liocalymene clintoni.* The ostracods, *Mastigobolbina lata, M. vanuxemi* and *Zygobolbina conradi,* are also very abundant in these layers. All the fossils found are related or common to the *M. lata* zone of the Middle Clinton.

Age and origin. Vanuxem ('42, p. 75–78) in his original survey considered the Oneida as Clinton in age. The fact, that the Oneida overlaps formations varying from the Lower Silurian to Ordovician, and that it is closely associated by transition zones with the overlying shales (see above), is proof in itself that the Oneida is in part Clinton.

The finding of Clinton ostracods in the shale breaks in the upper part of the Oneida at various places should remove any remaining doubt.

The Oneida apparently originated as a basal conglomerate while the Clinton seas were gradually working their way eastward and encroaching upon the high land mass which lay in that direction. Some of the material comprising the Oneida probably collected as rubble and shingle at the margin of this ancient land area and was later picked up and worn smooth by current and wave action. The actual pebbles may have been carried long distances along the old shore line before reaching their present locations. The similarity in the composition of the Oneida and the Shawangunk conglomerates suggests that these may have had the same ultimate source. The greater thickness of the Shawangunk of southeastern New York may indicate that the source lay to the southeast rather than east. Even if this were true, some clastics probably were derived from the rock which formed the beach to the immediate east of the present area of the Oneida conglomerate.

Certainly the land mass which furnished the clastics was the controlling factor in the formation of the Oneida conglomerate. As long as it remained a high land mass accessible to the forces of erosion, the products of which were within reach of the sea, the Oneida conglomerate continued to form. Only when it was worn down did the Oneida sedimentation come to a close. That the Oneida formed throughout the Lower and Middle Clinton is indicated by the fossils found in the thin shale partings in the upper part. Ostracods of the *Zygobolba excavata* zone were found near Martville only six miles west of the true Oneida type of lithology. The fossils of the *Z. decora* zone were found at Verona and the assemblage of the *Mastigobolbina lata* zone at Willowvale. From this evidence it is apparent that the shore line was migrating eastward throughout the deposition of the Oneida.

A precursory examination of the Oneida conglomerate failed to reveal any appreciable differences in the strata of various ages. A careful petrographic study of the conglomeratic and sandy layers, however, might throw some light on the actual source rocks. Such a study should also include the Shawangunk and similar conglomerates such as the Green Pond in southeastern New York and Pennsylvania.

Neahga Shale

Definition. The Neahga shale was named by Sanford ('35, p. 170–74) from an outcrop in the Niagara gorge. It had previously been called the "Lower Green Shale" by Hall ('43, p. 59); the Clinton

shale by Grabau ('01, p. 96); the Sodus shale by Kindle and Taylor ('13); and the Furnaceville shale by Williams ('19, p. 47–48).

Extent and lithologic characteristics. The only good exposure of the Neahga shale is at its type locality in the Niagara gorge. At that place the formation is approximately six feet thick. The upper five to five and one-half feet consists of a smooth, slightly silty, slightly calcareous, green platy shale.

The typical Neahga grades downward into a silty, sandy, calcareous green shale. Although this portion of the formation is quite different from the typical smooth platy Neahga, it does not seem to justify a new formation name. It still has a shaly structure in the outcrop and any division would have to be arbitrary. There is no distinct contact.

In some respects this green, sandy part of the Neahga can be considered a transition zone between the Thorold below and the smooth platy Neahga above. Some of the thin layers are, as Alling ('36, p. 196) has pointed out, calcareous, argillaceous sandstones, whereas others approach the smooth, platy character of the Neahga. On the other hand both parts of the formation have the same green color and except for a few thin layers even the most sandy ones contain enough argillaceous material to preserve a shaly structure.

The Neahga shale thins both to the east and west of the Niagara gorge. To the west its only observed occurrence in Ontario is at DeCew falls where according to Williams ('19, p. 48) a green shale a few inches thick occupies the stratigraphic position of the Neahga. At Lockport there is no typical smooth platy Neahga, but about eight inches of green, silty, sandy shale similar in many respects to the lower part of the Neahga of the Niagara gorge is found between the Reynales and the Thorold.

Fauna. The fossils of the Neahga are few in number and poorly preserved. The *Coelospira* are the most common brachiopods. Sanford ('35, p. 170–74) believes that the *Coelospira* of the Neahga are different from those of the higher Clinton formations. According to the writer's observation there are possibly two *Coelospira* in the formation. One can not be distinguished from the typical *Coelospira hemispherica* and the other is probably *Coelospira plicatula* of Grabau ('01, p. 96). The fossils, however, are so poorly preserved that they do not lend themselves to minute differentiation. The pelecypods, *Pterinea emacerata* and *Cuneamya alveata,* are relatively abundant. *Holopea obselata* and *Tentaculites minutus* are also present. Some poorly preserved ostracods are also found. The two species, *Zygobolba excavata* and *Z. curta,* have been definitely identified from the formation.

Origin. The origin of the Neahga was probably closely allied to the Maplewood and will be discussed with that formation (see p. 37).

Maplewood Shale

Definition. The Maplewood shale was named by Chadwick ('18, p. 34) from an exposure in the Genesee gorge near Maplewood park. The shale at that place had previously been called "Lower Green Shale" by Hall ('43, p. 59) and the Sodus shale by Hartnagel ('07, p. 13–14).

Extent and lithologic characteristics. The Maplewood shale of the Genesee gorge closely resembles the Neahga of the Niagara gorge in lithology. It is the same smooth, slightly calcareous, green, platy shale.

The lower three feet, also resembling the lower part of the Neahga, is sandy and much more calcareous. Unlike the Neahga this portion of the Maplewood does not contain any thin sandstone layers. The sandy content increases gradually although not uniformly downward to the contact of the Thorold. At this contact silt to very fine sand makes up over 50 per cent of the matrix. An abundance of phosphatic nodules is characteristic of this lower Maplewood in Monroe county.

The Maplewood has a limited lateral extent confined, so far as known, to Monroe county. The thickness is extremely variable. The known maximum thickness of 21 feet is exposed in the Genesee gorge (section 5, p. 127). On Densmore creek (section 6, p. 131) only three and one-half miles to the east it can not exceed 18 feet. At Glen Edythe (section 7, p. 133) five and one-quarter miles from the gorge on the east side of Irondequoit Bay, it is about 15 feet thick. Near Fruitland only fourteen and one-half miles from the type locality the Furnaceville is separated from the Thorold by only three or four inches of green, silty and sandy, calcareous shale. Typical Maplewood is entirely missing. From Fruitland eastward nothing approaching the Maplewood or Neahga appears in the outcrops. At a few places silty, green shales do separate the Furnaceville and the Thorold as on Salmon creek (section 13, p. 140); also see (Gillette '40, p. 43–44). At no place were these shales found to exceed eight inches and usually they are much less. Furthermore their color is their only resemblance to the Neahga or Maplewood. They are usually fissile instead of platy and very fossiliferous in contrast with the almost barren Maplewood. At most localities these shales contain scattered oolites of hematite.

The stratigraphic position of the Neahga and Maplewood is the same. The lithologic character is similar. Both are equally variable in thickness. Both are only sparingly fossiliferous. In view of all

these similarities the advisability of continuing both names might be questioned. The Neahga, however, is confined to a limited area in Niagara county. The nearest outcrops are over 60 miles apart. A correlation is certainly implied, but it seems best to retain both names for local usage.

South of the line of outcrop several wells put down in search of gas discovered another occurrence of a smooth, platy, green shale occupying the stratigraphic position of the Maplewood and the Neahga. At Clyde in southern Wayne county a green shale was present, probably about two feet thick. In northeastern Ontario county five and one-half miles south of Clyde ten feet of green shale overlies the Thorold. Farther south in the now defunct Geneva gas field three wells which penetrated the Clinton, failed to show even a trace of green shale. From this it can be inferred that the green shale of northeastern Ontario county has the same variable thickness as the Neahga and the Maplewood.

Fauna. Fossils are rare in the Maplewood. Most of the few poorly preserved forms which were collected, came from the lower three feet of the formation. Several *Coelospira,* probably *hemispherica,* were found. The gastropod, *Holopea obsoleta,* is by far the most common fossil. Although the formation was carefully investigated no ostracods were located.

Origin. The origin of these variable green shales is certainly baffling. It is possible that a shale body once extended unbroken from Niagara county at least as far east as Wayne county and that it was scoured and eroded away before the Reynales was deposited. As already pointed out, the Maplewood and Neahga show a gradation with the underlying Thorold. Where neither the Maplewood nor the Neahga is present the Thorold shows no such gradation with the overlying formations. The upper limit of both of these shales is always sharp, and there is no apparent mingling. This evidence might be taken as showing that there was a complete withdrawal of the sea with an ensuing period of erosion.

There is another and to the writer a more plausible explanation. As previously mentioned the Thorold has an abundance of green, silty shale breaks and included green shale pellets. The color and lithology both megascopic and microscopic show great resemblance to the Maplewood. With the deposition of the Thorold the clastic material was evidently exhausted. The Maplewood may represent a relatively quiet area into which the currents and waves swept the light clay particles during the last stages of Thorold deposition. Such an

explanation would eliminate any necessity for the complete removal of the sea and for subaerial erosion.

Sanford ('35, p. 1070–74) has suggested that these formations were deposited in bays. The objection to this idea is that a bay by definition is land locked, and there is no evidence of a near-by land mass. The Thorold has a remarkably uniform thickness throughout both Niagara and Monroe counties. If such a thin formation has been subjected to the normal agents of erosion so soon after its deposition, it could not conceivably have preserved this uniformity of thickness.

Furnaceville Iron Ore

Definition. The Furnaceville iron ore was introduced as a formational name for the oolitic or lenticular iron ore of Hall ('43, p. 60–62) by Hartnagel ('07, p. 14). The term was derived from an occurrence in the old ore pits near Furnaceville in western Wayne county. Sanford ('35, p. 167–83) pointing out that the Furnaceville is always closely associated with the Reynales suggested making the Furnaceville a member of the Reynales limestone.

In the Genesee gorge the Furnaceville is underlain by three feet of rather typical basal Reynales and overlain by the *Pentamerus* portion of the same formation. This condition holds for only a short distance to the east where the hematitic limestone appears to gradually fade into a true limestone. A few miles farther to the east the Furnaceville is again found, but it occupies a position at the base of the Reynales.

There are two possible explanations for such a relationship. The lower part of the Reynales, as will be shown later, contains considerable iron, sometimes as pyrite, sometimes as thin stringers of hematite. The iron ore of the Genesee gorge may represent a concentration of hematite which is later than that of the Furnaceville farther to the east. The other possible explanation is that while the Furnaceville was slowly forming to the east the lower Reynales was being deposited in the vicinity of Rochester and to the west. A slight change in conditions near the close of the Furnaceville could bring about the concentration of hematite in the gorge area. The thickness of this lentil is never great and with the exception of the one outcrop in the Genesee gorge the hematitic content is always low. In spite of a great deal of work on the fossils, lithology and field relationships the writer does not feel in a position to choose which of the two explanations is the more logical. If the former is accepted, then the iron ore in the gorge is younger than that at Fruitland and possibly deserves a separate designation.

The Furnaceville constitutes a lithologic unit easily recognizable and mappable. It can be traced for a long distance and with more

Figure 6 An ore pit near Fruitland, New York

assurance than most Clinton formations. For these reasons it seems preferable to use it as a formational name, to designate the lowermost hematitic limestone of the Clinton group. The Genesee gorge lentil because of its position and similar lithology is considered a part of the Furnaceville iron ore.

Extent and lithologic characteristics. The Furnaceville is a thin, highly variable, hematitic limestone. The variation in hematitic content is easily noted from outcrop to outcrop. In a single section the iron content is quite often found to be different for each layer. Locally there are exceptions, and the more uniform and richer areas of the Furnaceville, where the overburden of rock and till is not too great, have been utilized at one time or another as a source of iron oxide for more than a century. (See figure 6, p. 39.)

The variation in hematitic content of the Furnaceville is largely the result of foreign matter in the ore body. Thin shale breaks and layers of nonhematitic-bearing limestone serve to reduce the concentration of iron. There are other iron bearing minerals present in the Furnaceville, but they are relatively unimportant. They have never been found in any locality in such quantities even to suggest that their presence could in any way account for the iron which in other localities had gone into the formation of hematite.

Taken as a whole, the Furnaceville is dominately a fossiliferous ore, the hematite having replaced brachiopods, bryozoans, crinoids, ostracods etc. The small spherical or slightly flattened spherical, beadlike bodies, called oolites, however, are always found mingling with the replaced fossils. In some outcrops such as the Genesee gorge (section 5, p. 127) and Fruitland (section 8, p. 134) the oolites are comparatively rare. In others such as at the Devoe and Sterling Station ore pits (section 21 and 22, p. 154–57) the oolitic forms account for more than 50 per cent of the total hematite in some layers.

The degree to which the fossils of the ore have been replaced is also variable. At a few localities only the outer surface of the shell is found to have been replaced. Excellent examples of such can be found near the center of Furnaceville on Densmore creek (section 6, p. 131). The hematite forms only a thin film on both the outer and inner surfaces of the large, well preserved *Strophеodonta*. More commonly the fossils are entirely replaced. In a few localities the process appears to have gone a step beyond, and not only are the fossils completely replaced, but also thin concentric bands of hematite surround the fossils. The writer has counted as many as six layers surrounding a single cylindrical bryozoan. The round and cylindrical fossils are the only ones which show this particular phenomena. Excellent examples occur in the lower part of the Furnaceville at Fruitland.

The Furnaceville can be traced as a formation as far west as western Monroe county. It is represented in the Genesee gorge (section 5, p. 127) by a section fourteen inches thick. To the east on Densmore creek (section 6, p. 131) the hematitic content is considerably less and at Glen Edythe (section 7, p. 133) is entirely absent.

Well records show that the Furnaceville reappears as a hematitic limestone in extreme eastern Monroe county. At the ore pits between Fruitland (section 8, p. 134) and Ontario, it reaches a maximum of 20 inches in thickness with a relatively high iron content. To the east the formations can be traced by means of outcrops (sections 11 and 12, p. 137, 139) to Salmon creek (section 13, p. 140) in the eastern part of the Pultneyville quadrangle. The hematitic content is low in this area and on Salmon creek it is represented by approximately one foot of strata, the upper six inches being a hematitic limestone, the lower being a calcareous shale with interbedded stringers of oolitic hematite.

The outcrops to the east of Salmon creek are less common, but the Furnaceville horizon can be traced by well logs to the Devoe ore pit (section 21, p. 154) which is located on Bear creek a tributary of Black creek. In the old ore pits the formation is about 20 inches thick but the concentration of hematite is noticeably less than in the Fruitland pits. The ore at this place contains a considerable amount of argillaceous material. A short distance eastward in western Cayuga county at Sterling Station (section 23, p. 157) the Furnaceville is 36 inches thick and again has a relatively high iron content. The last known outcrop of the Furnaceville to the east is at Lunn's quarry in Oswego county (section 25, p. 160) a few miles from Sterling Station. There the formation is represented by a very argillaceous, slightly hematitic limestone with argillaceous and calcareous sandstones.

By means of the diamond drill cores which were put down under the direction of Newland and Hartnagel ('08, p. 4) and which were made available to the writer through the courtesy of C. A. Hartnagel, the formation can be traced to the east as far as Lakeport, Madison county (figure 7, p. 43). At South Granby (section E, p. 180) the ore is oolitic with a few fossils. It is only about eight inches thick but shows a high concentration of hematite. At Brewerton (section F, p. 182) the formation is represented by about 15 inches with a high iron content. At Lakeport (section G, p. 183) only about four inches can be assigned to the Furnaceville but it is relatively rich in hematite.

The lower contact of the Furnaceville is sharp and the formation appears quite distinct from any of the rock underlying it. As previously pointed out, it rests on the lower part of the Reynales in the Genesee gorge. To the east of Monroe county the ore in many places

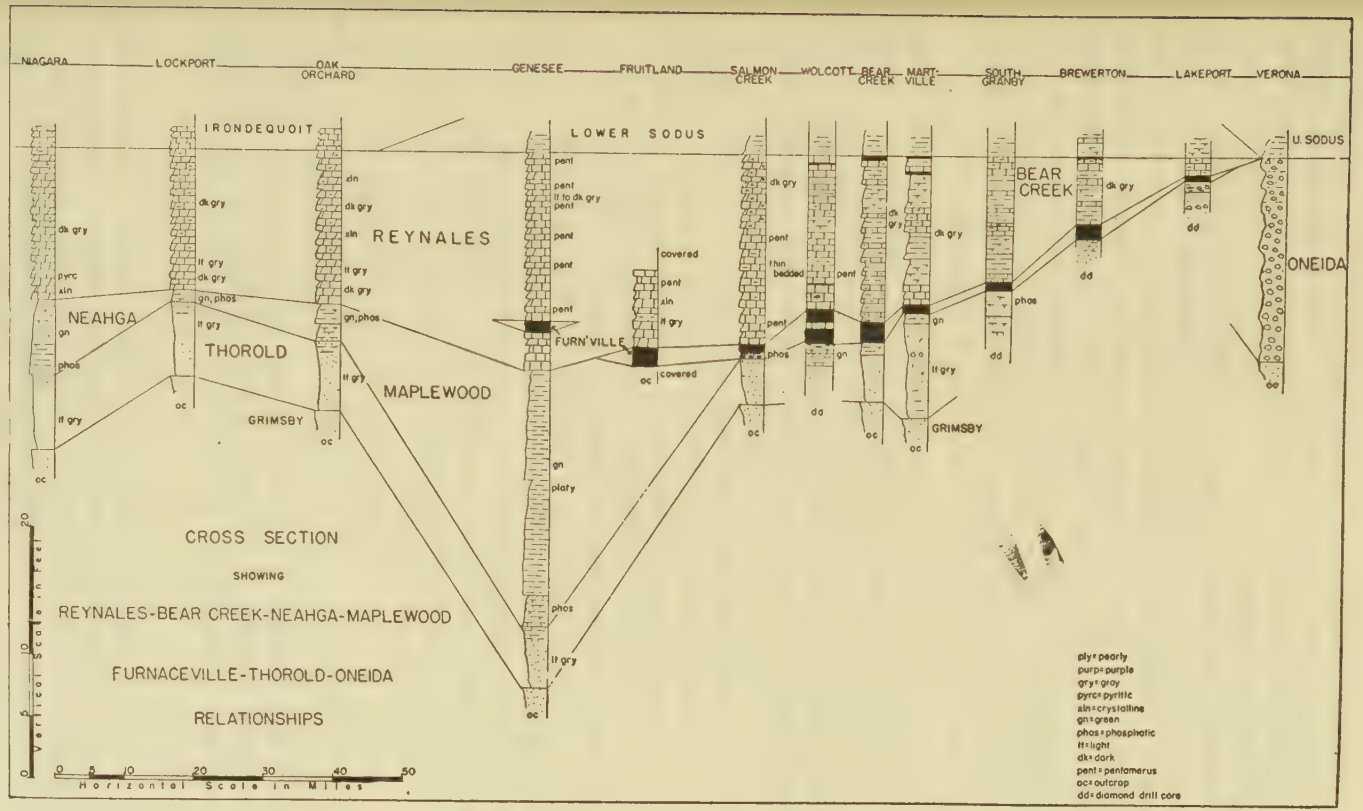

Figure 7 Cross section showing Reynales-Bear Creek-Neahga-Maplewood-Furnaceville-Thorold-Oneida relationships

is in direct contact with the Thorold sandstone. In a few localities it is separated from this basal sand by a few inches of green thinly laminated fossiliferous shale. The thickness of this shale is not known to exceed ten inches.

In the outcrops there is never any difficulty in deciding upon the upper limit of the Furnaceville, but east of Fruitland the lower two and one-half to three feet of Reynales is in many places impregnated with stringers of hematite. This seems to indicate that there was a transition from the hematitic forming conditions to those of the typical Reynales. In eastern Wayne county the Reynales grades laterally into the Bear Creek shale. This shale is in contact with the Reynales as far east as Lakeport where both the Bear Creek and the Furnaceville appear to pinch out against the Oneida conglomerate (figure 7, p. 43).

Fauna. The fauna of the Furnaceville is plentiful and varied. At a few outcrops the fossils are of normal size and well-preserved. More commonly they are poorly preserved and hard to identify specifically. Many of the more fragile fossils were apparently crushed and broken into fragments before they were replaced by hematite. The less fragile ones have the appearance of having been subjected to some form of abrasion, which removed their finer markings. In addition to the normal marine fauna of the Furnaceville some outcropping layers contain dwarf fossils. These dwarf forms are always confined to definite layers. They are similar in every respect except size to those occurring in the overlying or underlying strata.

Except for crinoid stems bryozoans are the most abundant of all megascopic fossils. The common species are *Helopora fragilis, Phaenopora ensiformis* and *P. explanata.* Brachiopods are also plentiful with *Coelospira hemispherica* outnumbering all others. *Strophcodonta corrugata* is more restricted but in a few localities this form is the dominant fossil.

The Furnaceville is the lowest of the Clinton formations in which there is a good microfauna. All of the more common ostracods of the *Zygobolba excavata* zone have been identified from this formation. They are particularly abundant and well preserved in the ore pits at Fruitland (section 8, p. 134). For a complete list of the fossils occurring in this and other formations, the reader is referred to table 3, p. 18–21).

Origin. The origin of the Furnaceville is closely associated with that of all Clinton iron ores. This subject has been the source of much scientific discussion in the literature. It does not lie within the scope of this report to go into a detailed discussion of that topic. Those who are interested, will find excellent discussions by Newland

and Hartnagel ('08, p. 45–53), Smyth ('92, p. 487–96) and Singewald ('11, p. 301–8).

In recent years the sedimentary origin of the Clinton iron ores has been in favor with most geologists. The results of the present study seem to confirm the sedimentary hypothesis. The fossils which make up the typical fossiliferous iron ores probably were replaced before they were covered by the overlying strata. This is shown not only by the intimate association of these replaced fossils with the oolites of hematite, but also by the fact that some of the fossils themselves appear to have acted as the nucleus for concentric bands of hematite similar to the concentric banding of the oolites. It is presumed that since oolites of hematite are known to be forming at the present time in a lake in Switzerland they are probably of primary origin. The relatively common interbedding of unreplaced fossiliferous limestone and typical iron ores is certainly another strong argument in favor of a primary sedimentary origin. In a few places some secondary replacement was observed. On Densmore creek near the middle of the formation is a highly fossiliferous layer which shows some secondary hematite. The concentration of iron decreases toward the center. Joint planes show a high concentration of iron immediately surrounding them. Such occurrences are rare and appear to be very recent in origin.

As a formation the Furnaceville was deposited in a narrow area extending from Monroe county on the west to Madison county on the east. The original north and south extent is not known. To the north erosion has probably removed considerable. To the south gas wells encounter a hematitic iron ore at the Furnaceville horizon more than forty miles from the line of outcrop. While the Furnaceville was forming in this narrow area, the clastic Oneida was being laid down to the east, and the lowest portions of the more normal marine Reynales was being deposited to the west.

The broken, worn and rubblelike condition of the fossils of the Furnaceville shows that the sea was probably very shallow and that waves and currents were active. The variable character of the formation may indicate that the currents and other forces acting in the shallow water tended to divide the sea into local areas or small basins which were more or less connected but which possessed a certain definite set of individual characteristics. In some local areas one class of organisms flourished and in others a wholly different class dominated. In some conditions were such that very few oolites of hematite formed; in others these were in abundance. In some basins very little argillaceous, calcareous and other foreign matter collected; in others the foreign matter greatly exceeded the hematitic material.

However vague and uncertain the actual conditions which led to the formation of this hematitic limestone may be, one fact stands out clear and undeniable. The Furnaceville was connected, as all other Clinton iron ores were, with the movement of the strand line. In Furnaceville time the sea was advancing and spreading eastward.

Reynales Limestone

Definition. The lowest Clinton limestone was called by Hall ('43, p. 62–64) the "Pentamerus Limestone of the Clinton Group." Hartnagel ('07, p. 14–15) named the formation the Wolcott limestone. When he introduced this designation, he was not aware of the fact that there were two *Pentamerus* limestones in Wayne county. Newland and Hartnagel ('08, p. 21–23) discovered the existence of two such limestones but did not assign geographic names to them. Chadwick ('18, p. 344–45) restricted the use of Wolcott to the upper *Pentamerus* limestone of Wayne county and introduced the name, Reynales, for the lower. Although the designation was taken from Reynales Basin, he clearly stated that one must visit the outcrops at Lockport and the Genesee gorge to see the entire section exposed. From this statement it is clear that Chadwick intended the Reynales to apply to the Lower Clinton limestone of the Lockport area. In the Rochester area he restricted the Reynales to apply only to the limestone which lay above the Furnaceville iron ore.

Chadwick also ('18, p. 342–43) introduced the term, Bear Creek shale. This was to apply to a shale underlying the Furnaceville on Bear creek, which he stated was Black creek of the topographic map. This locality about five miles northeast of Wolcott had been mentioned previously by Newland and Hartnagel ('08, p. 68). Hall ('43, p. 76–77 and '52, p. 83) apparently had this same outcrop in mind when he described the pelecypod fauna "in the shales beneath the ore bed at Wolcott." Chadwick carried the name, Bear Creek, west and applied it to the three feet of a somewhat argillaceous limestone underlying the Furnaceville at Rochester.

Under the main ore horizon at the old Devoe ore pit (section 21, p. 154) located on a tributary of Black creek which is still known locally as Bear creek, there are just eight inches of shale and thin sandy limestone on top of the Thorold sandstone. These layers are only slightly fossiliferous and contain no pelecypods. The argillaceous limestones and particularly the shales lying above the ore, which was once mined, abound in pelecypods. A very good collection of all the species listed by Hall can be made in a short time. About 13 feet above the main ore bed is another thin hematitic limestone. Although

pelecypods are found above this latter, they are much more numerous below. From these observations it seems quite probable that Hall's pelecypod fauna came from the shale above the main ore bed and below the thin hematitic layer. These same relationships can be seen at Sterling Station (section 23, p. 157).

Ulrich and Bassler ('23, p. 331–34) suggested that the Bear Creek might be used as a designation for the shale carrying many of the same pelecypods but lying entirely above the Reynales of Monroe and Wayne counties. Only a small part of this shale is exposed on Bear creek.

Sanford ('35, p. 177–78) objected to the Bear Creek as it was applied to the three feet of limestone under the Furnaceville at Rochester. He proposed using the Reynales as a formational name and making members of both the Furnaceville iron ore and the Brewer Dock, a name which he suggested for the limestone beneath the Furnaceville.

The Reynales in this report will be used to designate the lowest Clinton limestone formation of western New York. A typical exposure on Johnson creek at Middleport a few miles east of Reynales Basin is used as the type locality. It is suggested that the Brewer Dock, as defined by Sanford, be retained for use in discussing the local geology of Rochester and vicinity. In that area the Brewer Dock is separated from the rest of the Reynales by the Furnaceville. In other parts of western New York where such a condition does not exist, the use of Brewer Dock is not justified and would be confusing. The much misused Bear Creek (see p. 46) is redefined to apply to the argillaceous facies of the Reynales as exposed on the creek which is still locally known as Bear creek. It should be pointed out that Bear creek is not Black creek of the topographic map as stated by Chadwick ('18, p. 342–43) and Sanford ('35, p. 177–78) but a tributary of Black creek (section 21, p. 154).

Extent and lithologic characteristics. In the Niagara gorge the Reynales is about 12 feet thick and is dominantly a dark gray, dolomitic limestone. The basal three feet is pyritic, phosphatic and finely crystalline. It is sparingly fossiliferous but contains a larger number of species than all the rest of the formation. The next five feet is massive-bedded, fine to coarse-grained dolomitic limestone. Overlying this part is three feet of fine-grained, thin-bedded limestone. Many of the individual layers in this portion contain a large amount of argillaceous and silty material. The upper 12 inches is composed of crystalline limestones.

At Lockport the Reynales possesses much the same lithology. The lower two and one-half feet contains pyritic and phosphatic material

with few fossils. Immediately above are a few thin fossiliferous beds, some of which abound in *Hyattidina*. The upper part of the formation remains unchanged.

A short distance east of Lockport the first great change is noted in the Reynales. On Johnson creek at Middleport the formation is still about 12 feet thick. The lower eight feet consists of interstratified, medium gray, silty, dolomitic limestone with thin shale layers separating them. Some of the limestones are composed almost entirely of fossils. *Hyattidina*-bearing layers are very common. Residues of this part of the formation show a great range in the composition of the rocks. Most of the very fossiliferous beds are over 90 per cent soluble in hydrochloric acid. The residue consists dominantly of argillaceous material with minor amounts of silt, sand and chert. The dark gray, dolomitic, nonfossiliferous strata contains much more insoluble material, and some had as much as 60 per cent noncalcareous material. Residues of these also have a considerable amount of argillaceous material, but fine silt is of almost equal abundance. Pyrite and phosphatic nodules are present in minor amounts. The upper four feet of the formation is much less fossiliferous and dense dolomitic limestones are the dominant rock type.

The Reynales passes through another change in lithology between Middleport and Rochester. In the Genesee gorge the three feet of the formation underlying the Furnaceville ore, the Brewer Dock member, has much of the lithologic characteristics of the lower eight feet at Middleport. Dark, argillaceous layers are interbedded with crystalline, medium gray limestone. Some of the layers bear *Hyattidina,* but this fossil is not found so abundantly as in the section at Middleport. Above the Furnaceville are over 13 feet containing the *Pentamerus* layers interbedded with crystalline dolomitic limestones. Some of the crystalline limestones are fossiliferous, but most of them are barren. A few argillaceous unfossiliferous limestone layers are present. Thin shale partings are found throughout the entire thickness.

At the Fruitland ore pits the lower four feet of the formation is thin-bedded. Shale partings or breaks are abundant. Some of the limestone layers are sandy. Fossils are common and most of them are silicified. Overlying this portion are two feet of *Pentamerus*-bearing limestone.

Between Fruitland and Salmon creek there are numerous partial exposures of the formation. The silicified character of the fossils including *Pentamerus* is especially noticeable. The complete section exposed on Salmon creek shows the upper six feet of the formation to be a dark gray, dense, dolomitic, siliceous limestone with an abundance of chert. It is almost barren of fossils. Below this, the formation is more variable in composition. Calcareous shales, thin-crystal-

line, fossiliferous limestones and gray siliceous limestones are interbedded. There are two *Pentamerus*-bearing layers, the fossils of which are only slightly silicified. In the lower three feet of the formation thin stringers of hematitic material are abundant. At the very top of the formation is a thin, lean hematitic layer.

Dark gray shales appear as definite layers rather than as thin shale partings in the Wolcott core. They constitute two feet of the total eleven (section B, p. 159). Since they have the typical lithology of the shale that dominates the rocks equivalent to the Reynales on Bear creek and farther to the east they are significant. The lower two feet of limestone is impregnated with hematitic stringers and closely resembles the Reynales of Salmon creek. Immediately above this is one and one-half feet of limestone which contains the only *Pentamerus* in the Wolcott section. At the very top of the formation is a nine-inch layer of limestone with a thin hematitic layer overlying it.

The amount of shale increases rapidly eastward. On Bear creek, a tributary of Black creek, only five miles northeast of Wolcott the formation is too argillaceous to be designated as the Reynales limestone. Since lithology is the basis for defining formations, the rocks equivalent to the Reynales limestone on Bear creek and eastward are discussed under the heading of Bear Creek shale.

The hematitic limestone occurring at the top of the Reynales on Salmon creek and in the Wolcott core and, as will be discussed later, in the upper part of the Bear Creek shale, is worthy of note because of its remarkable persistence. Chadwick ('18, p. 345) named this hematitic horizon the Sterling Station iron ore. The only objection to considering it as a formation is its thinness, and the fact that it often occurs as stringers imbedded in the uppermost portion of the underlying formation and not as a distinct unit in itself.

In the Niagara gorge the Reynales is underlain by the Neahga. The break between the two formations is sharp, but the relationship is one of apparent conformability. At Lockport the Reynales rests on a thin, green, sandy shale which grades downward into the Thorold. The actual contact of the Reynales and this green, sandy shale is not well exposed. On Johnson creek, near Middleport, the Reynales again overlies a green, sandy shale. Although the lithologies of the shale and the limestone are distinct, and there is little or no question as to the exact contact, the two formations are perfectly conformable. Near the western limit of Monroe county the Maplewood enters the section and separates the Reynales from the underlying Thorold. Throughout the lateral extent of the Maplewood the contact with the Reynales is sharp, but the two formations are also apparently conformable. From the Wayne county line eastward the Reynales is underlain by

the Furnaceville. The Furnaceville is closely related to the Reynales and in some localities the two seem to grade vertically into each other.

In Orleans and Niagara counties the Reynales is overlain unconformably by the Irondequoit limestone. The contact is marked by a wavy surface and the evident truncation of the upper layers of the Reynales. Sanford ('39, p. 77–85) has reported the presence of pebbles of the Reynales in the overlying Irondequoit. Near the western boundary of Monroe county the Lower Sodus enters the section and from that point eastward overlies the Reynales. The contact between the Lower Sodus and the Reynales is always sharp, but there is no evidence of any erosional unconformity. Where the highest layers of the Reynales are marked by a concentration of hematite as on Salmon creek (see p. 49) and in the Wolcott core (section B, p. 159) the hematite is associated with the underlying Reynales and not with the Lower Sodus. No stringers of hematite are found above the contact.

Fauna. The fauna of the Reynales is as variable as its lithology. In the Niagara gorge it is practically barren of fossils. *Coelospira hemispherica* and *Stropheodonta corrugata* are sparingly present. Other forms have been described from these rocks, and a few other species were identified by the writer (section 1, p. 120). No ostracods were found.

At Lockport fossils are much more in evidence, particularly in the thin fossiliferous layers above the basal three feet of the formation. In addition to the species enumerated in the foregoing paragraph *Hyattidina congesta* is very common. Ostracods are rare (section 2, p. 123).

Hyattidina congesta reaches its most abundant development in the vicinity of Reynales Basin. The section exposed at Middleport (section 3, p. 126) contains layers abounding in this species. Crinoid stems are also very numerous, and rival the foregoing brachiopods as rock-forming constituents. Ostracods are rare.

At Rochester *Pentamerus oblongus* is the characteristic fossil of the formation. *Hyattidina congesta* has been found in the Brewer Dock member but in greatly reduced numbers. *Coelospira hemispherica* and *Stropheodonta corrugata* representing the most persistent forms of the Reynales are recognized in both the Brewer Dock member and the higher portions of the formation. *Rhynchotreta robusta* is another common form. Ostracods are much more abundant than in the outcrops to the west, and all four species, characteristic of the *Zygobolba excavata* zone, *Z. excavata, Z. curta, Z. inflata* and *Z. prolixa,* were found (section 5, 6 and 7, p. 127, 131, 133).

Eastward the fauna of the Reynales becomes more diversified. At Fruitland (section 8, p. 134) bryozoans are extremely abundant in the thin strata beneath the *Pentamerus*-bearing rock. *Fenestella tenuis* and *Semicoscinium tenuiceps* are two of the most important. Aside from *Pentamerus oblongus* the four brachiopods, *Stropheodonta corrugata, S. profunda, Coelospira hemispherica* and *Rhynchotreta robusta* are characteristic. The same ostracods are present and are even better preserved than in the sections in the vicinity of Rochester. This is probably explained by the fact that the ostracods at Fruitland are preserved in limestone whereas shale is the containing rock in the Rochester area.

On Salmon creek (section 13, p. 140) bryozoans are rare. The same four brachiopods still form an important part of the total assemblage. *Pentamerus oblongus* abounds in only two layers. The three corals, *Cannopora junciformis, Favosites favosideus* and *Zaphrentis bilateralis* are important. Perhaps the most significant addition is the appearance of pelecypods in considerable numbers in the dark gray shale partings between some of the limestone layers. *Pterinea emacerata, Ctenodonta lata* and *C. mactraeformis* are present. The same ostracods were also collected, but they are neither so common nor so well preserved as at Fruitland.

Origin. The Reynales was laid down in the Lower Clinton sea as that body reached its maximum expanse in New York and Ontario. Limestone and dolomite deposition extended from west of Kelso, Ontario (M. Y. Williams, '19, p. 48–49) to Wolcott in Wayne county. To the east argillaceous material was more plentiful and the Bear Creek shale was forming contemporaneously. Still farther to the east the very clastic Oneida was being laid down along the shore of an ancient land mass.

The close of the Reynales was marked by a partial elevation of the geosyncline and the consequent shrinking of the Lower Clinton sea. In Madison, Onondaga, Cayuga and eastern Wayne counties this shrinking of the sea brought the conditions suitable to the formation of sedimentary hematite which is found at many localities impregnating the uppermost layers of the Reynales and its eastern equivalent the Bear Creek. In some places these conditions persisted long enough to form thin relatively rich hematitic limestone layers which are found capping the Reynales and Bear Creek. The absence of the higher lithologic units of the Lower Clinton suggests that marine conditions may have been forced completely from Ontario and the westernmost counties of New York.

The upper surface of the Reynales in western New York unquestionably shows the effect of erosion. It is undulating and wavy.

Pebbles of the Reynales are found in the overlying Irondequoit. A careful study of this contact has never furnished evidence of any of the overlying Lower Clinton formations. Had these formations been deposited it would seem that there should be some indication of their past existence. Such has never been reported nor found.

Within the sea of Reynales deposition there must have existed a great variety of conditions. This is shown not only by the many types of limestones and dolomites represented, but also by the radical change in fossil content from place to place and layer to layer. It seems reasonable that the crystalline *Pentamerus* layers would require an entirely different set of conditions than that which would produce the dense, unfossiliferous, dolomitic layers.

Certain fossils such as *Coelospira hemispherica* and *Stropheodonta corrugata* were not so exacting in their requirements, and because of this these forms are found in a greater variety of sediments. In fact they are present in all but the most unfossiliferous layers in the Reynales. They are much more abundant, however, in some layers than in others, which would indicate that they also preferred certain living conditions.

Many of the other organisms living at the time were much more exacting in their requirements. *Hyattidina congesta* and *Pentamerus oblongus* serve as examples. Even in areas where these fossils are found, they are confined to very definite layers which tends to show that only at certain intervals were conditions exactly suited to their special needs. The whole class of bryozoans were equally selective of their environment as were also the pelecypods.

This variation in faunal content has been noted by others. Sanford ('35, p. 177–84) would explain these changes by the age of the inclosing strata. The Reynales may be older to the west and younger to the east, as he contends, but there is apparently no way of proving this. All of the fossils common to the Reynales, including the ostracods, are found in the overlying formations with one possible exception, *Hyattidina congesta.* Sanford's views are more fully discussed in an earlier publication (Gillette, '40, p. 52–53).

Ulrich and Bassler ('23, p. 333–34) have explained the presence of *Pentamerus* and bryozoans in the Reynales as a result of a southern connection for the sea. The overlying Lower Sodus with its *Coelospira* and various ostracods, they claim, is indicative of an Atlantic source. Both *Coelospira* and ostracods are found throughout the Reynales and Bear Creek. The *Pentamerus* have a limited lateral extent in New York and in Ontario (M. Y. Williams, '19, p. 48–49). The two areas where the Reynales yields *Pentamerus,* are separated by an area of considerable greater lateral extent which yields no trace of these

fossils. The distribution of these fossils plus the intimate mingling of faunas which they supposed had either definite Altantic or southern origin, can certainly be more easily explained on the basis of ecology.

Bear Creek Shale

Definition. The Bear Creek was originally named by Chadwick ('18, p. 342–43). He used it as a designation for the dark pelecypod-bearing shales which were supposed to underlie the Furnaceville in the town of Wolcott. As pointed out (p. 46) no such shale exists beneath the Furnaceville, but there is a shale formation above the ore which contains the fauna. The Bear Creek is redefined to apply to the pelecypod-bearing shales and argillaceous limestones on Bear creek, a tributary of Black creek in the eastern part of the town of Wolcott in Wayne county.

Extent and lithologic characteristics. The Bear Creek (section 21, p. 154) at its type locality is a dark gray, thin-bedded, silty, slightly calcareous shale with argillaceous limestone layers. Both the shales and limestones are pyritic. The shales are very fossiliferous and the limestones are sparingly so. The lower seven feet are about half shale and half argillaceous limestone. The next six feet are mostly shale. The top of the formation is marked by an eight-inch limestone layer which in turn is overlain by three inches of hematitic limestone.

The Bear Creek is also well exposed except for the basal two or three feet in the ore pits at Sterling Station (section 23, p. 157). Limestones form even a smaller percentage of the total rock. The shales are very fossiliferous. At the top of the formation is a seven-inch limestone layer overlain by approximately three inches of hematitic material. The upper limestone layer is argillaceous and slightly sandy. It weathers brown. It is noteworthy because it has produced a few *Pentamerus*.

Near Martville (section 25, p. 160) the formation possesses the same lithologic characteristics and fossils. To the east it is possible to trace the Bear Creek as far as Lakeport (figure 7, p. 43). The formation pinches out entirely before reaching the outcrops at Verona Station. In correlating the Bear Creek in the diamond drill cores extensive use was made of the hematitic concentration at the top and at the bottom of the formation.

The lower limit of the Bear Creek is easily established. Everywhere it rests conformably upon the Furnaceville iron ore, and thin stringers and layers of sedimentary hematite are found reaching upward into the shale. The upper contact is also marked by a hematitic horizon. At many places this upper concentration occurs as a zone consisting

of shales and interbedded thin layers and stringers of hematitic material in the upper part of the Bear Creek.

Fauna. The Bear Creek is a shale characterized by its pelecypod fauna. Among the most abundant pelecypods are *Ctenodonta lata, C. mactraeformis, Pyrenomoeus cuneatus, Pterinea emacerata, Modiolopsis subalatus* and *Orthodesma curtum.* Lingulas are also important fossils and the species, *Lingula oblata* and *L. perovata,* are found in considerable numbers in some layers. *Coelospira hemispherica* and *Stropheodonta corrugata* range throughout the formation. *Phaenopora ensiformis* and *Tentaculites minutus* are two other common fossils. The ostracod fauna is rich and includes all the species common to the *Zygobolba excavata* zone. *Z. excavata, Z. curta, Z. prolixa, Z. inflata* and others are represented.

Origin. The origin of the Bear Creek is closely associated with that of the Reynales. It evidently formed in the same Lower Clinton sea nearer to the shore and to a source of argillaceous material. The turbulent conditions which resulted, were not suitable to many of the organisms which lived in the comparatively clear seas of the contemporaneous limestone. On the other hand, it did produce an environment much to the liking of the mud-loving pelecypods.

Lower Sodus Shale

Definition. The Sodus shale was named by Hartnagel ('07, p. 13). He intended the term to apply to the lower green shale of Hall ('43, p. 59–60). Both Hall and Hartnagel thought that the Maplewood of the Genesee gorge was the western equivalent of the *Coelospira*-bearing shales of Wayne county. Chadwick ('18, p. 345–46) recognized the fallacy of this contention and restricted the Sodus to the *Coelospira*-bearing shales of Wayne county.

Ulrich and Bassler ('23, p. 369–72) discovered that Chadwick's Sodus shale of the Genesee gorge contained quite a different assemblage of ostracods from that of the Sodus on Second creek in Wayne county. At Rochester the Sodus contained ostracods belonging to their *Zygobolba anticostiensis* zone, the *Z. excavata* zone of this report (see page 24). The Sodus shale which they collected in central Wayne county was found to have those fossils characteristic of their *Z. decora* zone. Because of these microfossils and "in the absence of an unquestionable geographic name" they designated the Sodus of the Genesee gorge as the *Z. anticostiensis* zone. It was suggested that Chadwick's Bear Creek might be the correct name for the *Z. anticostiensis* zone. This suggestion was based upon a comparison of the fauna which they collected from the *Z. anticostiensis* zone with the faunal list of Bear

Creek species given by Chadwick. The term, Sodus shale, was restricted to apply only to those shales containing fossils of the *Z. decora* zone.

The writer ('40, p. 54–68) agreed with Ulrich and Bassler that the lower part of the Sodus contained a microfauna related to their *Z. anticostiensis* assemblage and that the upper part of the Sodus possessed only species common to their *Z. decora* zone. Furthermore, it was pointed out that the two shales were separated by a slight unconformity. The two shales were designated as the Lower and Upper Sodus shales. The type locality of the Lower Sodus was established on Salmon creek (section 13, p. 140).

Since the formations are based upon lithology the separation of the Lower and Upper Sodus shales is subject to some question. Careful studies reveal that there are some minor lithologic differences as will be shown later, but taken as a whole they are dominantly green shales with comparatively thin fossiliferous limestone layers. Even the slight unconformity which separates them on Salmon creek may be of local significance. To the east the section thickens and possibly sedimentation continued throughout the time represented by the unconformity. In the thicker sections the break in microfauna may not be so marked. In fact there may even be an overlapping of ranges and an intermingling of forms. Unfortunately there are no outcrops of the Lower and Upper Sodus contact to the east of Salmon creek and the data derived from well cuttings and cores are inconclusive. In the absence of more definite information to disregard the unconformity on Salmon creek and to give one name to the shales separated by it would be misleading. In using the designations, Lower and Upper Sodus, similarities are implied.

Extent and lithologic characteristics. The Lower Sodus shale is not present a short distance west of the Monroe county line. It appears in western Monroe county and attains a thickness of approximately 18 feet in the Genesee gorge (section 5, p. 127). In that outcrop it is principally a green to greenish gray calcareous, slightly silty, fossiliferous shale with thin limestone layers. The green shales often contain as much as 25 per cent calcareous material and a few residues have shown as much as 40 per cent. Dark gray so-called purple shale layers are interbedded with the green. These dark layers increase downward and the basal four to five feet is dominated by that color. In composition these so-called purple layers are less calcareous. Residues never show as much as 20 per cent calcium carbonate and average less than 10 per cent. They carry more slit-size particles and are slightly more siliceous. The limestone layers vary from a fraction

of an inch to three inches in thickness. In the upper three feet of the formation there are three prominent layers which contain over 95 per cent calcareous material. These three layers are composed almost entirely of *Coelospira* and represent what have been commonly called "pearly layers." There are other thin limestones which contain no *Coelospira*. These are not so pure in composition. In the lower 10 feet the limestones are very scarce and do not exceed one-half inch in thickness. In this portion they are very argillaceous and some even take on the color of the shale.

Between the Genesee gorge and Salmon creek (section 13, p. 140) there is little change in the Lower Sodus. At Salmon creek it is approximately 20 feet thick. The lower six feet consists of dark gray shale. Throughout the rest of the formation dark gray and green shales are interstratified with the green dominating toward the top of the section. The pearly layers are confined to the upper part of the formation. They appear thicker than in the Genesee gorge and one which forms the very top of the formation, is seven inches thick.

In Oswego county the Lower Sodus is over 25 feet thick. Here also the lower part is dominantly a dark gray shale with the upper part containing the same green to greenish gray layers. The *Coelospira*-bearing limestones are confined as in other areas to the upper part. In the lower 10 feet at Lunn's quarry (section 25, p. 160) thin very fine-grained sandstones or silt stones are present. These partings which are usually less than a quarter inch thick, are limonitic in the weathered outcrop. The fossils which cover the surfaces of the silt stones, are preserved as limonitic casts and molds. The shale layers themselves contain many fossils which are similarly preserved. In the less weathered exposures pyrite is very common. It is likely that the limonitic casts and molds were originally pyritized fossils.

By means of the diamond drill cores the Lower Sodus can be traced as a formation as far east as Lakeport in Madison county. At that place the ostracods show that there is at least 11 feet and not more than 15 feet of Lower Sodus. Between Lakeport and Verona Station, Oneida county, the formation pinches out. In general the cores show that the typical greenish gray shales gradually disappear eastward. The dark gray shale layers dominate the whole section between Brewerton (section F, p. 182) and Lakeport (section G, p. 183). The limestones even in the uppermost part of the formation lose their clear, crystalline, pearly character and become brown to brownish gray in color and much more sandy.

As already pointed out in detail, the contact of the Reynales and the Lower Sodus is sharp but conformable in Monroe and western Wayne counties. In central Wayne county the contact of the Rey-

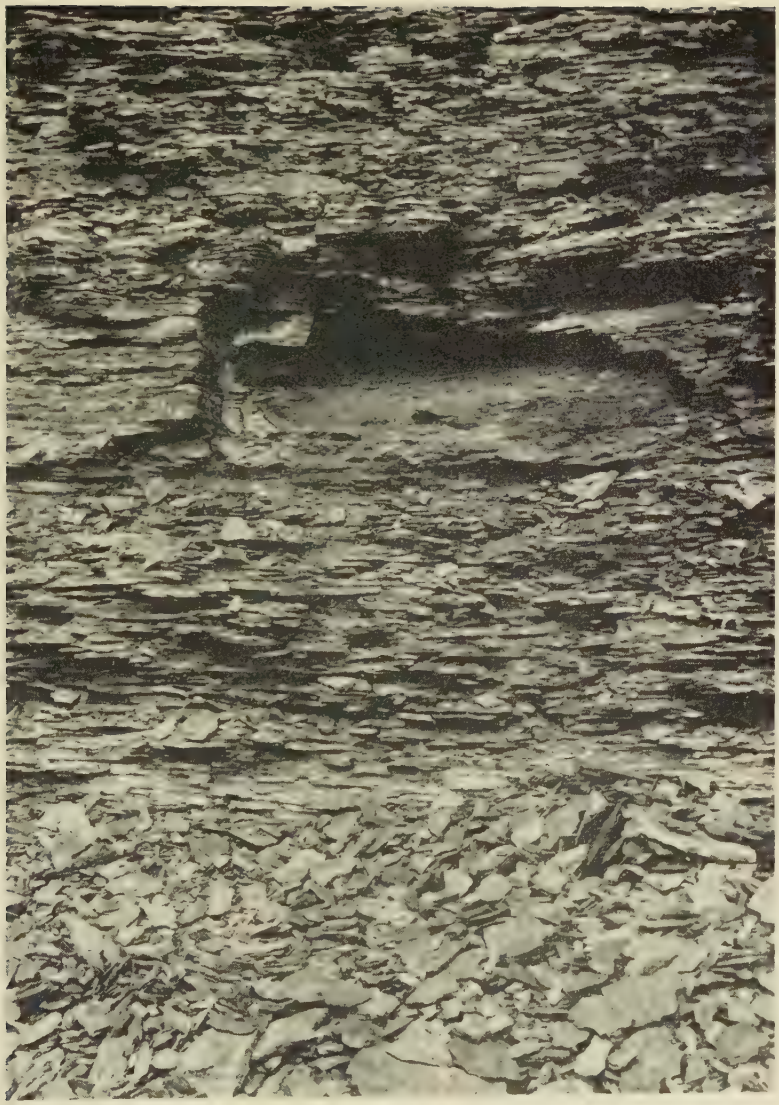

Figure 8 Genesee Gorge. Williamson-Lower Sodus contact. Note three inch shell rubble separating formations

nales and the Lower Sodus is marked by a thin hematitic limestone. In eastern Wayne county the Reynales becomes a shale, the Bear Creek. This latter formation underlies the Lower Sodus eastward beyond Lakeport, where both appear to wedge out against the Oneida. In most cores the boundary between the two formations is marked by a concentration of hematite in the upper part of the Bear Creek.

In the Genesee gorge the Lower Sodus is immediately overlain by the Williamson shale of the Upper Clinton. The boundary is marked in some places by a shell rubble which attains a maximum thickness of three inches (see figure 8, p. 57). At other places small pebbles up to a centimeter in diameter are found lying on the upper surface of the Lower Sodus. In still other places a more or less sharp break in the stratigraphic sequence is the only evidence of the erosion to which the strata must have been subjected prior to the deposition of the Williamson. In Wayne county the Lower Sodus is separated from the Upper Sodus by an erosional unconformity, as shown by the wavy surface of the underlying shale. To the east of Wayne county there are no exposures of the contact and its character is unknown.

Fauna. The Lower Sodus is a highly fossiliferous formation. The actual number of individual species collected, however, is not so great as in some of the less fossiliferous formations of the Clinton. Furthermore, not a single species collected from the Lower Sodus is confined to that formation.

The brachiopods are the most abundant of all classes of organisms represented. The common Lower and Middle Clinton *Coelospira hemispherica* and *Stropheodonta corrugata* are present in great numbers throughout the section. The bryozoans are equally well represented by the cylindrical *Phaenopora ensiformis* and others. *Tentaculites minutus* of the conularia is another species which abounds in all types of rock. At Lunn's quarry it is so plentiful that thin layers are found made up almost entirely of this poorly understood fossil. The pelecypod fauna is rich and varied but unlike the others these are restricted and occur only in the dark gray shale layers. They reach their maximum development in the basal part of the Sodus in Wayne and Monroe counties. The species are identical with those which were found in the Bear Creek shale. The most common forms are *Ctenodonta machaeriformis, Pyrenomoeus cuneatus, Cyrtodonta alata* and *Pterinea emacerata.*

The microfauna is also plentiful. The ostracods abound in both the green and dark gray shales and also in the limestone layers. In the shales they are usually represented by natural casts. In the pearly layers their actual shells are often obtainable. The most common

species are *Zygobolba excavata, Z. curta, Z. inflata, Z. rectangularis* and *Z. prolixa.*

Origin. Ulrich and Bassler ('23, p. 269) believed that the Sodus formed as a result of an Atlantic invasion. They based their arguments on the differences in the fauna of the Sodus shales and the Reynales limestone. This latter formation, they considered, had a southern origin. As already shown the Reynales bears ostracods which were supposed to be of Atlantic origin. The *Coelospira* and *Stropheodonta* are both found in abundance in the underlying Reynales. The pelecypods are the same. *Tentaculites minutus* and *Phaenopora ensiformis* are also common to both. In fact if there are any forms confined to the Lower Sodus, they are very rare. Certainly sedimentary environment could easily explain any differences which exist.

The writer believes that following the general shrinking of the Lower Sodus sea at the close of Reynales-Bear Creek deposition, a gradual depression of a small part of the geosyncline permitted the formation of the Lower Sodus. It is possible that the sea was forced completely from New York at the close of the Reynales, but if this occurred it soon returned. The thin upper portion of the Bear Creek and the Reynales which contains the stringers of hematite, can be traced uninterruptedly for long distances. Even the thin hematitic limestone, found capping the Reynales and Bear Creek, shows no evidence of erosion.

Since both the Bear Creek and the Lower Sodus wedge out against the Oneida between Lakeport and Verona Station, it seems safe to say that the eastern shoreline was somewhere in the vicinity of Verona Station. Although the upper few feet of the Oneida contain ostracods of the *Zygobolba decora* zone, probably a large part of the conglomerate outcropping at Verona Station actually formed contemporaneously with the Bear Creek and the Lower Sodus. The western limit of the area receiving sediments must remain a matter of pure speculation. The Lower Sodus pinches out rapidly west of the Genesee gorge. In Orleans and Niagara counties the Reynales is directly overlain by the Irondequoit of Upper Clinton age. Without a doubt erosion has modified the original distribution of the formation (see p. 50).

Iron was not so plentiful in the restricted Lower Sodus seas as in the Reynales, but in eastern Wayne and Oswego counties the finely disseminated pyrite in the unweathered rocks indicates that the metal was present in considerable quantities. Its presence as pyrite rather than hematite indicates that most of the rocks were deposited under reducing conditions.

The occurrence of identical dark gray shales with the same pelecypod fauna in both the Lower Sodus and Bear Creek suggests that conditions which brought about their formation were similar. These shales with their linguloid brachiopods and many pelecypods which probably represented a slimy environment, formed throughout the early part of the Lower Sodus in western Wayne and Monroe counties, and reoccurred at intervals to the very close of the sedimentation. At times, as represented in the upper part of the Lower Sodus in Monroe, Wayne and Cayuga counties, the sea became less ladened with mud and silt. This resulted in the deposition of the green calcareous shales. In restricted areas and for short intervals the sea became so free from argillaceous, siliceous or other clastic material that the pearly limestone layers formed. The fossils in these limestones are not broken or worn and for this reason they apparently lived where they are found, and were not swept into certain sheltered areas by current action. The fact that these layers can not be traced for any distance tends to point to the conclusion that the environment under which they formed, was local.

Upper Sodus Shale

Definition. The Upper Sodus shale was named by the writer ('40, p. 58–63) from the typical exposures on Salmon and Second creeks in the town of Sodus, Wayne county. The term was applied to the upper part of the Sodus shale of Hartnagel ('07, p. 13) and Chadwick ('18, p. 345–46) and corresponds to the restricted Sodus of Ulrich and Bassler ('23, p. 331–33).

Extent and lithologic characteristics. The Upper Sodus is absent in the Genesee gorge, but it enters the section a short distance to the east. At Fruitland in extreme western Wayne county it reaches an estimated thickness of 20 feet. It continues to thicken eastward, and in the vicinity of Salmon (section 13, p. 140) and Second (section 14, p. 142) creeks, the type localities, it is 34 feet thick (figure 9, p. 62).

The lithology of the Upper Sodus at the type locality closely resembles that of the underlying Lower Sodus. The lower part is dominantly a green to greenish gray, calcareous, highly fossiliferous shale with the same pearly layers. In this basal portion there are a few dark gray or purple shale layers, but they are less abundant and always much thinner than in the underlying formation. Upward in the section the dark gray layers disappear entirely. In the upper ten feet bluish gray, highly fossiliferous shales gradually replace in importance the greenish gray shales. This bluish gray shale in the

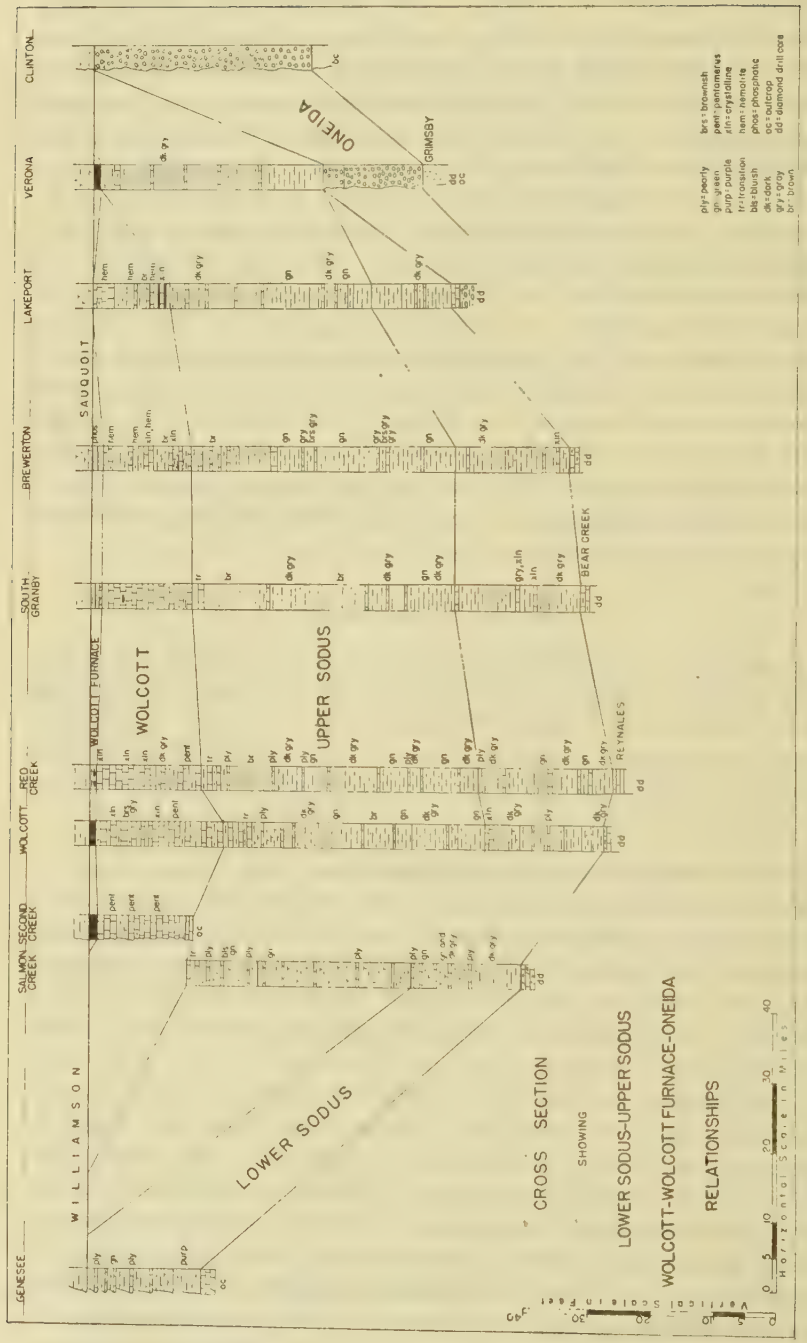

Figure 9 Cross section showing Lower Sodus-Upper Sodus-Wolcott-Wolcott Furnace-Oneida relationships

unweathered section, as in the cores, is a brownish gray. The pearly layers continue throughout the Upper Sodus to within four feet of the top, but become less numerous upward. Other non-*Coelospira*-bearing limestones appear in the section near the middle of the formation. They become more abundant upward. Some are light gray, unfossiliferous, clear, crystalline limestones. Others are fossiliferous with a brown to yellowish brown color. As in the Lower Sodus the pearly layers average 90 per cent calcareous material. Residues of the non-*Coelospira*-bearing limestones show that their carbonate content is considerably less. The crystalline limestones are on the average about 85 per cent soluble in hydrochloric acid. The brown to yellowish brown layers vary from a low of 68 per cent to a high of 83 per cent. The residues of the pearly and clear crystalline limestones consist almost entirely of fine siliceous silt. The impurities of the brown to yellowish brown layers are clay, pyrite, limonite and silt in the order named.

In the Red Creek core (section C, p. 178) the Upper Sodus is between 42 and 44 feet thick. It attains its maximum thickness in eastern Cayuga and western Oswego counties, where it is estimated to be about 50 feet. The whole formation is not exposed anywhere in this area, but fragmentary outcrops show that the lithology is similar to that of the type localities.

At South Granby (section E, p. 180) there are about 42 feet of the Upper Sodus. At Brewerton (section F, p. 182) about 42 feet and at Lakeport (section G, p. 183) about 32 feet can be assigned to the formation. In this area the Upper Sodus undergoes some lithologic changes. The silty, slightly calcareous, dark gray or purple shales which were so rare and confined to the lower part of the formation at the type localities are found in increasing abundance eastward. At Lakeport there is a total of less than six feet of the typical green to greenish gray shale. The pearly layers also decrease, and at Lakeport there is only one true pearly layer near the middle of the formation.

At Verona Station (section H, p. 185; section 31, p. 164) the thickness of the Upper Sodus shale is 36 feet. This includes some shale which is equivalent to the Wolcott limestone (see p. 68). The shale is uniformly dark greenish gray in color with thin limestone layers. None of these can be considered pearly layers. The shale is silty, and the thin limestones are very sandy. In the upper three feet of the formation there are a number of thin, calcareous, ferruginous sandstones interbedded with the shale. The sandstones are very fossiliferous containing an abundance of ostracods.

The Upper Sodus pinches out rapidly against the Oneida conglomerate east of Verona. It is entirely missing at Willowvale.

Where the Lower Sodus lies beneath the Upper Sodus, the basal contact has been discussed in detail (p. 59). To the east of Lakeport the Upper Sodus rests on and interfingers with the Oneida conglomerate. The thin shale layers, bearing the typical microfauna of this formation, are found separating the uppermost layers of the conglomeratic Oneida at Verona Station (section 31, p. 164). The contact of the Wolcott and Upper Sodus is everywhere gradational. The boundary is always arbitrarily placed where the limestone layers predominate over the shale. In the vicinity of Verona Station the formation is overlain by the Wolcott Furnace iron ore or its eastern equivalent, the contact is easily determined, but there are stringers of hematite in the upper few feet of shale.

Fauna. Like the Lower Sodus the Upper Sodus is very fossiliferous, but the number of individual species is not great. Brachiopods are the most abundant of all megascopic fossils. *Coelospira hemispherica* and *Stropheodonta corrugata* again are found to dominate the class. The bryozoans are more plentiful in the Upper Sodus. *Phaenopora ensiformis* and *P. constellata* are found throughout the formation, but the latter is rare except in the upper part. *Fenestella tenuis* and *Semicoscinium tenuiceps* are confined to the bluish green shale layers in the upper ten feet of the formation. *Holopea obsoleta* is the only true gastropod found in any abundance. This form is so common that a few layers in the upper part of the Sodus at Second creek (section 14, p. 142) are composed almost entirely of this fossil. *Tentaculites minutus* is still an important fossil. Pelecypods play a much less important role in the Upper Sodus than in the Lower Sodus.

Ostracods are very plentiful. Most of them are preserved as natural casts, and if they were not present in such great numbers, specific identification would be difficult. *Zygobolba decora, Z. robusta, Z. intermedia* and *Z. inflata* are found ranging from the very base to the top of the formation. *Mastigobolbina incipiens* and *M. retifera* are also present, but these two forms occur only in the upper part. Of all the ostracods occurring in this formation only *Z. inflata* is found in the underlying Lower Sodus.

Origin. The unconformity at the base of the Upper Sodus in Wayne county points to the conclusion that marine conditions temporarily left the area after the deposition of the Lower Sodus. The sharp break in microfauna adds to this conclusion. There is no way of determining even relatively the duration of time represented by this small break. Ulrich and Bassler ('23, p. 369–72) point out that their *Zygobolba anticostiensis* zone corresponding to the *Z. excavata* zone (p. 24) of this report is separated from the *Z. decora* zone by

600 feet of calcareous shale and limestone on the island of Anticosti. Of course this evidence may be misleading, and the absence of ostracods in the rocks intervening between the two zones may be due to any one of many causes. In other words the true range of either or both may not be shown at Anticosti.

There is the possibility that the sea did not withdraw completely from New York State. On Fish creek (section 9, p. 135) near Fruitland the formation is overlain by the Wolcott limestone and is roughly 20 feet thick. At Wallington it is 34 feet and in Cayuga county it is approximately 50 feet. At all of these places the two ostracods, *Mastigobolbina incipiens* and *M. retifera,* which appear to be restricted to the upper portion of the formation are present. This points to the conclusion that the Upper Sodus probably reached its maximum development near its close. It may be that a slight relative elevation of the land may have forced the seas from western New York into deeper parts of the basin to the east or possibly to the south. Another slight shift in the relative position of land and sea would have caused the sea to spread out once more into western New York.

Similarities in megascopic fauna and lithology suggest that throughout most of Wayne, Cayuga and Oswego counties the Upper Sodus probably formed under conditions very like those of the Lower Sodus. The same green shales and pearly layers are dominant. Toward the close of Upper Sodus sedimentation bluish gray shales were being deposited, and these are the first evidence of a change in environment which was to culminate in the formation of the Wolcott limestone. The bluish gray shales while containing *Coelospira* and other forms common to the Lower Sodus are characterized by the presence of lacy bryozoans.

The gradual change in the character of the formation is noted eastward. In Oneida county conditions were vastly different from those of Wayne county. Here in addition to the characteristic fossils, pelecypods and cephalopods are found in abundance. The pearly limestones are entirely absent. The shales are dark greenish gray and contain a greater percentage of silt and fine sand.

Wolcott Limestone

Definition. Hartnagel ('07, p. 14) named the Wolcott limestone. He intended the designation to supplant Hall's ('43, p. 62–64) descriptive title "Pentamerus Limestone of the Clinton Group." Both Hall and Hartnagel failed to recognize that there were two *Pentamerus* limestones in the Clinton. Newland and Hartnagel ('08, p. 21–23) discovered this fact but did not give geographic names to the formations. Chadwick ('18, p. 347–48) restricted the Wolcott and applied

it to the upper *Pentamerus* limestone occurring in Wayne county and incidently to the only limestone bearing these fossils outcropping within the town of Wolcott.

Extent and lithologic characteristics. Nowhere in the vicinity of Wolcott are the entire 22 feet of the formation exposed. By studying the outcrops on Mudge (section 17, p. 149), Wolcott and Little Wolcott (section 19, p. 151) creeks, a good idea of the lithology can be obtained. The diamond drill core which was recovered near Wolcott (section B, p. 159) adds greatly to the understanding of the lithologic characteristics of the formation.

The Wolcott at its type locality is a limestone with an abundance of shale layers. The lower three and one-half feet consists of brownish or bluish gray, very argillaceous, fossiliferous limestone with thin crystalline limestones and brownish or bluish gray (see p. 63), slightly silty, calcareous to very calcareous shale. The shale accounts for nearly 50 per cent of the total thickness. In the next ten feet coarse, crystalline, fossiliferous limestones dominate the section accompanied by the same brownish gray, calcareous shales. In this portion slightly over seven feet are limestone and the remainder shale. The upper nine feet of the formation are thin-bedded. Crystalline limestones, brown argillaceous limestones and brownish gray shales occur in equal amounts. The two types of limestones account for nearly six feet of the total.

To the west of the type locality the thickness of the Wolcott decreases. On Second creek (section 14, p. 142) it is approximately 15 feet. With the thinning the formation appears to have become less shaly. Above the basal three feet, which are half shale, are seven feet of massive-bedded limestone with only a few shale partings separating the layers. In the upper five feet limestone accounts for slightly more than three feet of the total. On Salmon creek (section 10, p. 135) in the town of Williamson the Wolcott is only seven feet thick, and the shale is found only as partings between the massive limestone layers. At Fruitland on Fish creek (section 9, p. 135) it measures only six feet, the upper 18 inches of which are limestone and the remainder about half limestone and half shale. The Wolcott pinches out between Fruitland and Rochester and is entirely missing in the Genesee gorge (figure 9, p. 62).

East of the type locality the Wolcott can be recognized in the Red Creek (section C, p. 178) and South Granby (section E, p. 180) diamond drill cores. The limestone layers become more argillaceous and the crystalline layers less common. The relative proportion of the brown shale increases east of Red Creek. In both of these cores the Wolcott is roughly 16 feet thick. Between South Granby and

Brewerton as revealed by the Brewerton core, the Wolcott becomes a brown, very calcareous shale with a few limestone layers. The formation is capped by an iron ore as in the Wolcott area but throughout the upper half of the formation are thin stringers of hematite. Fourteen feet are assigned to the Wolcott at Brewerton.

In the Lakeport core (section G, p. 183) the Wolcott is 10 feet thick. Here the limestones are even less prominent and those which do occur are all brown to yellowish brown in color. All the limestones carry some trace of hematite and at the base of this section a lean iron ore is developed. Two very thin, calcareous sandstones are present, one at the base and the other about five feet higher in the section. The basal sand is hematitic and roughly two inches thick. The other measures approximately an inch. Between Lakeport and Verona Station the Wolcott either pinches out completely or becomes so shaly that it can not be distinguished from the Upper Sodus.

Except at Lakeport the lower limit of the Wolcott is everywhere indefinite and passes gradationally downward into the underlying Upper Sodus. At Lakeport the break between the two formations is sharp. A thin hematitic sandstone separates them.

Where the Wolcott is overlain by the Wolcott Furnace iron ore its upper contact is also gradational. In a few places where the ore is entirely missing, the contact with the overlying formations is sharp and unconformable, and is marked by an abrupt change in lithology.

Fauna. Since the only outcrops of the Wolcott limestone are in Wayne county, the discussion of the fauna must be largely confined to that area. In reality the formation possesses two assemblages of fossils, one more or less confined to the limestone layers, the other to the shales. *Pentamerus oblongus* is by far the most abundant of all the fossils. There are many limestone layers composed almost entirely of this fossil. Besides their typical occurrence in the crystalline limestone layers, they are sparingly found in the brown argillaceous limestones. At only one place were they found in the shales. The shale layer containing them, outcrops on Mudge creek (section 17, p. 149) and although having a definite shaly structure it is 46 per cent soluble in acid. Brachiopods most commonly associated with *Pentamerus* in the limestone layers include *Rhynchotreta robusta, Atrypa reticularis* and *Rhipidomella circulus.*

In the shale layers bryozoans are the most important fossil. Some layers on Second and Mudge creeks are found to be literally packed with lacy bryozoans, *Fenestella tenuis, Semicoscinium tenuiceps* and *Rhinopora verrucosa. Coelospira hemispherica* and *Stropheodonta corrugata* rank first in abundance among the brachiopods. *Leptaena rhomboidalis* and *Platystrophia biforatus* are also common.

Ostracods are not so abundant in the Wolcott as in the underlying formations. Only at Fish creek (section 9, p. 135) near Fruitland was the writer able to find these fossils in the limestone, and even there they were rare. In the shales, however, they occur at every outcrop. In these layers they are always natural casts or impressions and are poorly preserved. The species in order of their abundance are: *Zygobolba decora, Mastigobolbina incipiens, M. retifera* and *Z. robusta.*

Origin. The Wolcott type of sedimentation began evolving before the Upper Sodus came to a close. First the brownish or bluish gray shales (see p. 63) with their bryozoan fauna commenced forming at intervals and alternating with the greenish gray sedimentation of the typical Upper Sodus. The conditions conducive to the deposition of the brownish gray shale were dominant late in the Upper Sodus. Intervals of relatively clear water favorable to the formation of fossil limestones occurred throughout the Upper Sodus. The frequency of these intervals increased and lengthened. *Coelospira* were no longer wholly responsible for their formation, and other fossils played an increasing role even before the beginning of the Wolcott. When the limestone deposition was of such duration, that it resulted in the formation of more of this type of rock than shale, the Wolcott is considered to have arrived.

The exact extent of the Wolcott sea in western New York is problematical. It was most certainly subject to erosion before the deposition of the overlying formations. Some calcareous pebbles with a lithology of the Wolcott limestone were found in the Genesee gorge between the Lower Sodus and the Williamson. The pebbles suggest that the Wolcott sea extended at least as far west as the Genesee valley.

In central New York a different problem is involved in determining the extent of the Wolcott sea. The Wolcott as a formation can be traced as far east as Lakeport without difficulty. Some of the limestones remain characteristic of that place. Between Lakeport and Verona Station these limestones disappear. As previously pointed out, the shales of the Wolcott are very like those occurring in the highest portion of the Upper Sodus of Wayne county. The shale of the Wolcott passes through lithologic changes eastward, but so do the shales of the Upper Sodus. The result is that the two shales are indistinguishable at Verona Station. The microfauna of both the Wolcott and the Upper Sodus is the same. The megafauna is of no assistance. The long range and persistent forms of both formations are the only ones found common to Verona Station and in Wayne county outcrops. For these reasons it is impossible to

say how much of the rock found at Verona Station formed contemporaneously with the Wolcott limestone of Wayne county. Since there are no rocks at Willowvale containing fossils characteristic of the Wolcott or the Upper Sodus, the shore line must have been somewhere between that point and Lakeport.

Within the Wolcott seas of western New York conditions were radically different from those existing during the deposition of the underlying formation. In some restricted areas and for varying intervals of time *Pentamerus* thrived to the exclusion of most other forms. A short distance away the ecology was different and other organisms lived contemporaneously. This is illustrated strikingly on Mudge (section 17, p. 149) and Second (section 14, p. 142) creeks. On Second creek there is a rather spectacular three and one-half foot section composed of massive limestone layers bearing a profusion of *Pentamerus*. This section is located about five feet above the base. On Mudge creek there is no such mass of *Pentamerus*-bearing rock exposed anywhere. The corresponding three and one-half feet contain *Pentamerus* layers, but they are separated by shales and other limestones. On Mudge creek the lowest *Pentamerus* layer is 14 inches thick, and this is followed by 18 inches of shale. The shale is literally packed with bryozoans. On Little Wolcott creek the lowest *Pentamerus* is only eight inches thick, and it is followed by 12 inches of thin-bedded limestones and shales. The shales contain *Coelospira, Stropheodonta* and an occasional *Platystrophia.* Many attempts have been made to trace layers and successions of layers in outcrops and diamond drill cores. All were unsuccessful. These facts seem to suggest that the Wolcott was a sea which possessed many types of environmental conditions contemporaneously.

In the vicinity of Brewerton and to the east as shown in the Brewerton (section F, p. 182), Lakeport (section C, p. 178) and Verona Station (section H, p. 185) cores and outcrops at Verona Station, the limestones and shales abound in thin stringers of hematite. In the Brewerton core the stringers are confined to the upper five feet. At Lakeport they occur throughout the whole thickness with a lean ore about one-foot thick occupying a position immediately above the basal sand. At Verona Station there is no rock which can be definitely assigned to the Wolcott (see p. 68), but oolites are found in the shale underlying the main ore body for a distance of 14 inches. The presence of these hematitic layers would tend to show that conditions favorable to the formation of ores started occurring during Wolcott time in central New York. These are probably the first evidences of the retreat of the Lower Clinton

seas. Their geographic distribution suggests that they formed only a short distance from the actual shore line.

Wolcott Furnace Iron Ore

Definition. The Wolcott Furnace iron ore was named by Chadwick ('18, p. 347–49) from an exposure at Wolcott Furnace, where it was worked commercially for a short time. It had previously been recognized by Newland and Hartnagel ('08, p. 23), who had designated it as the upper hematitic seam.

At the same time Chadwick ('18, p. 346) named the Wolcott Furnace iron ore, he proposed the term Verona iron ore. This latter name was to apply to the ore mined at Verona Station. Chadwick considered this formation to underlie the Wolcott limestone which in turn was overlain by the Wolcott Furnace iron ore. As previously stated (p. 69) there is a concentration of hematite at the base of the Wolcott in the Lakeport section (section G, p. 183). At Verona Station (section H, p. 185) the iron ore is immediately overlain by the Sauquoit shale with its characteristic Middle Clinton fauna, and underlain by rocks which resemble the Upper Sodus. Whether the Verona is to be correlated with either the lean ore of the basal Wolcott in the Lakeport core, or directly with the Wolcott Furnace iron ore is a matter of conjecture. The writer prefers to hold as closely as possible to lithology in defining formations. On this basis it seems justifiable to designate all formations dominantly hematitic at the top of the Lower Clinton as the Wolcott Furnace iron ore. As with the Furnaceville iron ore if every lentil of hematitic-bearing rock were to be given a name, the literature would be burdened with many confusing terms whose significance would be highly questionable.

Extent and lithologic characteristics. The Wolcott Furnace iron ore outcrops at its type locality in the bed of Wolcott creek. It is only about a foot thick and is dominantly of the fossiliferous type. The calcareous content is always high but varies noticeably from layer to layer. At the very top of the formation is a two inch, dark gray, sandy layer with abundant phosphatic nodules.

To the west the Wolcott Furnace iron ore can be traced as far as Second creek (section 14, p. 142). Here it is 18 inches thick and consists of hematitic limestone and shale. At the center of the formation is a highly calcareous layer which shows a relatively high concentration of iron. The thin limestones and shales comprising the remainder of the rocks assigned to the formation possesses only scattered oolites of hematite. The formation has no positive representatives west of Second creek. In the Wallington core (section A,

p. 175) a few scattered oolites in the upper two feet of thin bedded Wolcott may possibly indicate the Wolcott Furnace horizon. East of Wolcott the formation also pinches out. In the Red Creek core (section C, p. 178) a thin seam about an inch in thickness overlain by a thin shaly layer containing phosphatic nodules is its only indication. To the south of the type locality this formation apparently extends about ten miles to where it disappears. The extent and distribution of this formation in the Clyde and Sodus Bay quadrangles is discussed in some detail in an earlier publication (Gillette, '40, p. 68–71).

At South Granby (section E, p. 180) the Wolcott Furnace horizon is marked by a hematitic layer about three inches thick. Here thin hematitic bands begin appearing in the upper layers of the underlying Wolcott. At Brewerton (section F, p. 182) the ore is again only three inches thick and the upper part of the underlying Wolcott is again impregnated with thin seams of hematitic material. In the Lakeport well (section G, p. 183) the horizon is represented by a layer of shale containing phosphatic nodules and a few oolites of hematite. In this well almost every limestone layer shows a hematitic content.

At Verona Station (section H, p. 185) the Wolcott Furnace was worked commercially for a number of years. It averages about 15 inches thick and is again dominated by the fossiliferous type. As in other areas the Wolcott Furnace is highly variable. Analyses and other data given by Newland and Hartnagel ('08, p. 67) show a rapid change in thickness and iron content within a radius of one-half mile. The Wolcott Furnace is not known east of Verona Station (figure 9, p. 62).

The contact of the Wolcott and the Wolcott Furnace is everywhere gradational. On the other hand the upper limit of the formation is always sharp and well-defined. In Wayne county a thin conglomeratic sandstone separates the Wolcott Furnace from the Williamson. In Oneida county the actual contact is now covered by water. The variation in thickness may indicate the effect of erosion. Certainly the change in lithology is abrupt.

Fauna. The fauna of the Wolcott Furnace iron ore closely resembles that of the underlying Wolcott. In Wayne county the hematitic limestone contains in order of abundance: the bryozoans, *Helopora fragilis* and *Phaenopora ensiformis;* the coral, *Chaetetes lycoperdon;* the brachiopod, *Coelospira hemispherica.* In the calcareous, hematitic shales on Second creek *Fenestella tenuis* and *Semicoscinium tenuiceps* are very common. These shales also yield

Coelospira hemispherica and other brachiopods. Ostracods are not found in this formation in Wayne county.

At Verona Station the assemblage is quite similar. The notable exceptions are the relative unimportance of the lacy bryozoans and the abundance of ostracods. *Zygobolba decora, Z. robusta* and *Mastigobolbina incipiens* are the most common forms and are diagnostic of the *Z. decora* zone.

Origin. The absence of any sharp break between the Wolcott and the Wolcott Furnace iron ore and the close similarity of their respective faunas suggest that they were deposited in the same sea. The hematitic phase appears to have been connected with the shrinking or withdrawal of the sea, which is interpreted as having brought about the formation of small, more or less isolated pools, in which hematite was deposited. As the recession began the first areas to feel the effect would be those shallowest and nearest the shore. This would account for the appearance of hematitic-bearing strata low in the Wolcott of the Oneida Lake area. The recession seems to have been accompanied by numerous readvances which temporarily restored normal marine environments. This would explain the presence of hematitic stringers in the shales and limestones in the eastern or near shore areas throughout the Wolcott. Considerably later elevation caused the sea to migrate westward and brought the hematitic-forming conditions to Wayne county. Finally this elevation forced the sea completely from New York.

MIDDLE CLINTON

Sauquoit Shale

Definition. Chadwick ('18, p. 341) proposed the name Sauquoit to apply to "all the sandstone and shale beds between the Oneida conglomerate and the oolitic ore bed in the Oriskany and Sauquoit valleys." The type locality was established on Swift creek north of Sauquoit village. Chadwick considered the formation as thus defined to embrace the eastern equivalents of the Sodus, Martville and perhaps Maplewood and other horizons. Ulrich and Bassler ('23, p. 337–39) through a study of the fauna came to the conclusion that these beds were Middle Clinton in age. They retained the term Sauquoit.

Since the Sauquoit is dominantly a shale, it is considered best to designate it as such. The formation does contain a few sandstone layers, and at Willowvale a number of conglomerates are present in the formation. Even so the sandstone and conglomerates form a small percentage of the total thickness (see figure 10, p. 73).

Figure 10 Willowvale. Sauquoit shale. Hammers mark upper surface of conglomeratic layer

Extent and lithologic characteristics. The Sauquoit, as exposed on a small tributary flowing into Sauquoit creek at Willowvale (section 34, p. 171), is truly a heterogeneous mixture of rock strata. It is dominantly a shale, but it contains sandy shales, calcareous shales, conglomerates, sandstones and even a few limestones. The formation can be divided into two parts, each possessing a certain dominant type of lithology and possessing certain faunal characteristics. It is quite possible that these two parts are distinct enough to justify formational names. Since Willowvale, however, marks the easternmost of the outcrops included in this report, and the exposures of rocks of Middle Clinton age are so few and fragmentary to the west, no subdivision is attempted.

At the base of the exposed section at Willowvale is a massive conglomeratic layer 18 inches thick. This may possibly represent the top of the Oneida, but from other outcrops in the vicinity it seems more likely that the true Oneida lies roughly ten feet below the lowest exposure. Overlying the conglomerate is 12 feet of highly fossiliferous, dark bluish gray shale. The shale is highly siliceous with the quartz present as very fine sand and silt. These shales are in turn overlain by 30 feet of dark bluish to greenish gray, silty and sandy shale. Conglomeratic layers are common and many of them occur as boulderlike masses completely surrounded by shale. The surfaces of the conglomeratic layers are always found to be very irregular. Wave and ripple marks together with mud cracks are much in evidence in this portion of the formation. Near the center of the interval is a number of sandy limestones and calcareous sandstones. The top of this lower part of the Sauquoit is poorly exposed (figure 11, p. 76), but its location is marked by the highest conglomeratic mass observed at Willowvale.

The upper part of the formation is a bluish green, fissile, slightly sandy, silty shale about 40 feet thick. Present are many thin sandstones, which never exceed two inches in thickness and average less than one-half inch.

At Verona Station (section 31, p. 164) the approximate thickness of the Sauquoit is 90 feet. Two divisions are noticeable but because of the fragmentary nature of the outcrops, the thickness of each could not be determined. The lower part is a bluish gray shale similar in many respects to the lower portion of the formation at Willowvale. There are no conglomerates, and there is a decided increase in the number of sandy limestone layers. The upper part is the same dark green, fissile shale found at Willowvale.

In the Lakeport core (section G, p. 183) the Sauquoit is 75 feet thick. The lower 50 feet are a bluish gray shale with thin limestones.

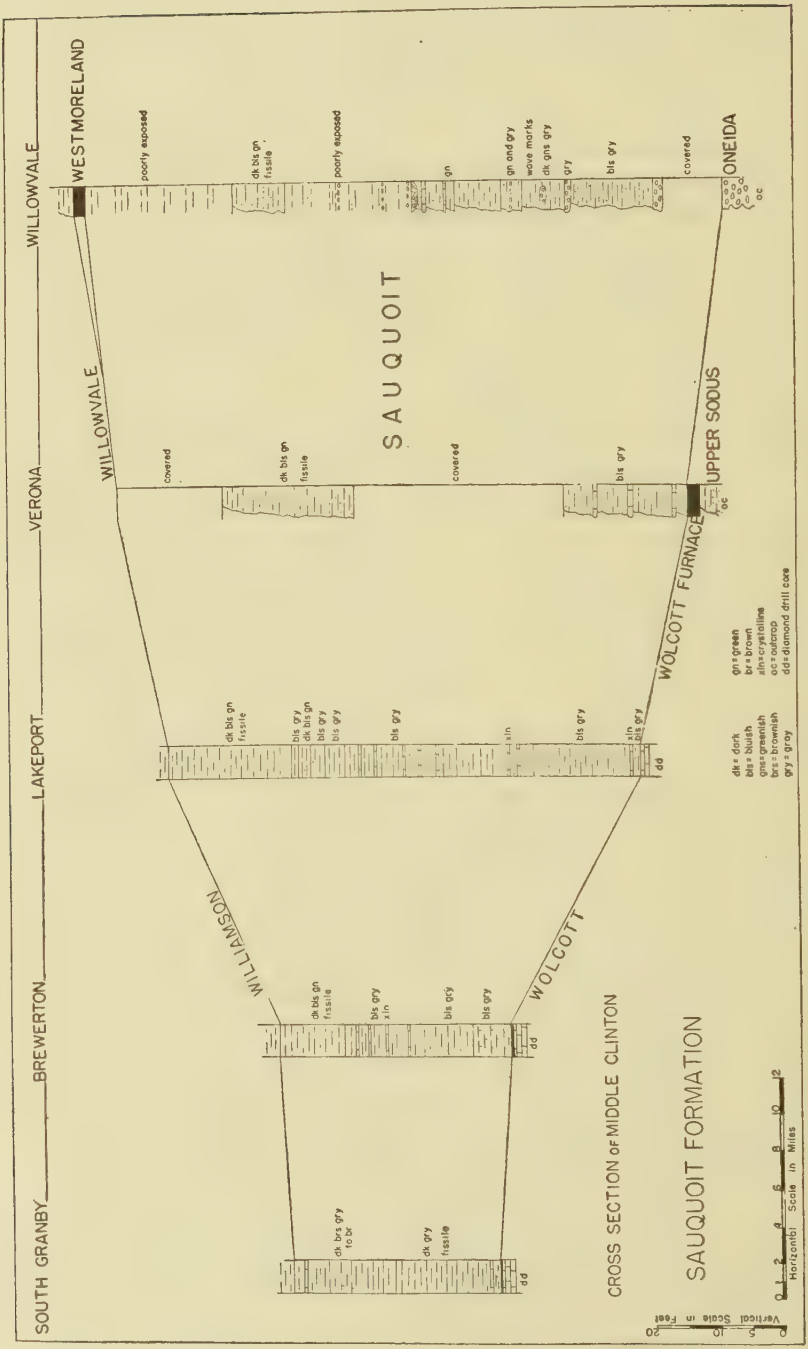

Figure 11 Cross section of Middle Clinton Sauquoit formation

This shale appears to grade into the dark bluish green, fissile portion, which accounts for the upper 20 feet (figure 11, p. 76).

At Brewerton (section F, p. 182) the Sauquoit is only about 36 feet thick. Even with this reduction in thickness the same two divisions are discernible. The upper fissile portion is represented by 10 feet (figure 11, p. 76). Between Brewerton and South Granby (section E, p. 180) the Sauquoit loses only four feet of thickness. The two divisions are not so easily recognized. The upper part is slightly more fissile than the underlying strata. The rock as a whole is more calcareous and less sandy. Between South Granby and Red Creek the formation pinches out completely.

In the vicinity of Willowvale the Sauquoit appears to grade downward into the Oneida conglomerate. At Verona Station and to the west the formation is separated from the underlying Wolcott and Wolcott Furnace by a sharp break which apparently represents an erosional unconformity. The upper contact is sharp and well-defined, wherever it can be seen. At Willowvale and Clinton the overlying formation is the Westmoreland iron ore. At Lakeport and Brewerton the Williamson is found in contact with the Sauquoit (section F, p. 182, section G, p. 183).

Fauna. Collectively the megafauna of the Sauquoit forms a distinct and recognizable unit, but when viewed as individual species few are found to be actually confined to the Sauquoit. Some range downward into the Lower Clinton and others upward into the Upper Clinton formations.

Pelecypods are more numerous than any other class of organisms. The long range *Ctenodonta machaeriformis* and *Pterinea emacerata* are very common. *Cyrtodonta alata* not identified from the Upper but well represented in the Lower Clinton is another very abundant fossil. Less in number but well represented are the Upper Clinton *Amphicoelia orbculoides* and *Leptodesma rhomboidea*. Brachiopods rank second. *Coelospira hemispherica* is particularly abundant in the lower part of the Sauquoit. This fossil is identical with the *Coelospira* found throughout the Lower Clinton. *Leptaena rhomboidalis, Rhipidomella circulus, Atrypa reticularis, Chonetes cornutus* and *Rhychonella bidens* are also common. The first three are long range species but the last two are confined to the Middle and Upper Clinton formations.

Two gastropods, *Bucanella trilobata* and *Cyclonema varicosum*, are well represented. These fossils appear in the overlying Upper Clinton but not in so great abundance.

Trilobites are comparatively rare. *Liocalymene clintoni* and a

species of *Dalmanites* which is closely related to *limulurus,* possibly *lunatus,* are the most common forms. Both have a decided Upper Clinton affinity.

Ostracods are found in great numbers throughout the entire thickness of the formation. Furthermore the forms present are confined to the Sauquoit and are so different from those found in either the overlying Upper Clinton or the underlying Lower Clinton that they can not possibly be confused. *Mastigobolbina lata* var. *nana, M. vanuxemi, M. clarkei, Zygobolbina conradi* are the important fossils of this class.

Origin. The sharp break at the base of the Sauquoit indicates that marine waters were forced from New York state by a relative elevation of the basin after the deposition of the Wolcott Furnace iron ore. In Pennsylvania, Maryland and other Appalachian regions Ulrich and Bassler ('23, p. 372–74) and F. M. Swartz ('34, p. 112–17) report the presence of rocks with *Zygobolba emacerata* assemblage (see p. 22) between those containing the *Z. decora* and the *Mastigobolbina lata* forms. From these observations it is possible that the Clinton sea did not completely withdraw from the Appalachian region but was forced into the deeper portion of the geosyncline which at that particular time lay south of New York.

Sometime during the Middle Clinton a renewed down warping of the geosyncline brought a return of marine waters to central New York. Since the deposits of the Middle Clinton are confined to a relatively narrow area, the sea probably flooded only a small part of the state. If the present distribution of the rocks is any guide, this invasion extended on the east into Herkimer county and on the west into Cayuga. That eastern Oneida county was relatively near to a land mass of considerable relief during the deposition of the lower part of the Sauquoit is shown by the abundance of conglomeratic layers. Furthermore, the presence of mud cracks, wave marks and ripple marks appear to indicate that eastern Oneida county was actually under shore conditions at times during the deposition of the lower part of the Sauquoit. Later the seas appear to have spread eastward. This would account for the covering of the conglomeratic mud cracked portion of the Sauquoit by the fissile-bedded strata which probably formed in an area at some distance from any beach or shore line.

The clastics in the lower part of the Sauquoit become less important westward from Willowvale. A few thin sandstones are found at Verona Station. Neither in the outcrop at Verona Station nor in the cores at Lakeport and Brewerton are there any conglomerates.

From these observations it seems safe to conclude that actual beach conditions never extended west of eastern Oneida county during the Sauquoit. Furthermore the reduction in the amount of coarse clastics westward tends to indicate the source of these lay to the east as in the Lower Clinton.

UPPER CLINTON

Williamson Shale

Definition. The name, Williamson shale, was proposed by Hartnagel ('07, p. 15) for the lithologic designation "Second Clinton Shale", of Hall ('43, p. 64–65). As Hartnagel then used the term in the Rochester area, it combined in a single unit the Williamson and the Lower Sodus shale. Chadwick ('18, p. 348–49) limited the Williamson to the graptolite-bearing shale lying above the Wolcott limestone in Wayne county.

Extent and lithologic characteristics. The Williamson shale enters the Clinton section between Oak Orchard creek in Orleans county and the Genesee gorge. In the gorge this formation is about six feet thick and is a dark green to black, calcareous to slightly calcareous, fissile, graptolite-bearing shale. The upper part, which is predominantly dark green, contains a few thin limestones. The limestones are particularly evident near the contact of the Irondequoit and the Williamson. Most of the truly black graptolite-bearing layers are in the basal portion. Some, but not all, of these graptolite shales have a central waferlike layer which is highly calcareous. The black argillaceous material which gives its color to the whole thin layer, appears to be firmly pressed into and frozen to both the upper and lower surfaces of the central calcareous matrix. On Salmon creek (section 10, p. 135) in the town of Williamson, the type locality, the formation is about seven feet thick and exhibits the same lithologic characteristics. The first change, worthy of note, appears in the outcrops on Second creek (section 14, p. 142). Here the Williamson is over 17 feet thick. The black, fissile graptolite-bearing rock is confined to a few feet in the lower part. The rest of the formation is dark green in color and is also very thin-bedded. Thin limestones some of which are composed almost entirely of *Plectambonites* range throughout the entire thickness. Whereas pyrite is sparingly present in the outcrops to the west, it is very abundant in this locality. Pyritized fossils are common in the shales. In addition several distinct layers of pyrite are present. Most of these are less than a quarter of an inch in thickness, but at least two are over a half inch thick. These layers which are composed of small almost perfect cubes of

pyrite, are conformable with the over and underlying strata and appear to be definitely sedimentary in origin.

The Williamson of Little Wolcott creek (section 19, p. 151) is roughly 25 feet thick. The most striking change is the disappearance of the black, fissile, graptolite-bearing layers. At this outcrop the bedding planes of the dark green shale layers are often found covered with graptolites. So plentiful are the graptolites that their black color tends to accentuate and emphasize the bedding planes of the dark green shale layers. Much of the shale is fissile, but some of it becomes thicker bedded and may be more correctly described as platy.

To the east, as shown in the Red Creek diamond drill core (section C, p. 178) the Williamson is about 32 feet thick, and possesses the same characteristics as those observed in the outcrops of Little Wolcott creek. Farther east, as seen in the South Granby (section E, p. 180) and Lakeport (section G, p. 183) cores, a separation of the shaly phase at the base of the Irondequoit and the true Williamson becomes increasingly difficult. It is evident, however, (figure 12, p. 81) that the thickness of the Williamson increases toward the east.

Between South Granby and Lakeport are two small but highly significant outcrops. One is located at Phoenix (section 28, p. 162) where the Barge canal was dredged out of the uppermost Williamson and the other is an outcrop of the lowermost Williamson at Brewerton (section 29, p. 163). At Phoenix the formation is a dark green, calcareous to slightly calcareous, platy, graptolite-bearing shale. It closely resembles the platy Williamson of Little Wolcott creek. It has the same thin limestones many of which are composed of *Sowerbyella*. At Brewerton it is likewise a dark green shale, but is inclined to be fissile with the graptolites confined to the bedding planes. Thin fossiliferous limestones are present. Both of these outcrops are of small vertical extent but they do serve to show that the sediments which are assigned to the Williamson and the Irondequoit in the cores, are approximately correct.

The Irondequoit and the Williamson as lithologic units lose their identity east of Lakeport. The eastern equivalent of these two formations is discussed under a separate title, the Willowvale shale.

The unconformity at the base of the Williamson is of considerable magnitude and clearly defines the lower limit of the formation. At Lakeport the Williamson rests on the Sauquoit. It overlaps westward the progressively older formations, the Wolcott Furnace iron ore, the Wolcott limestone and finally the Lower Sodus shale. The upper limit of the formation is not so easily and readily determined. At all outcrops and also in the cores it appears to grade upward into the

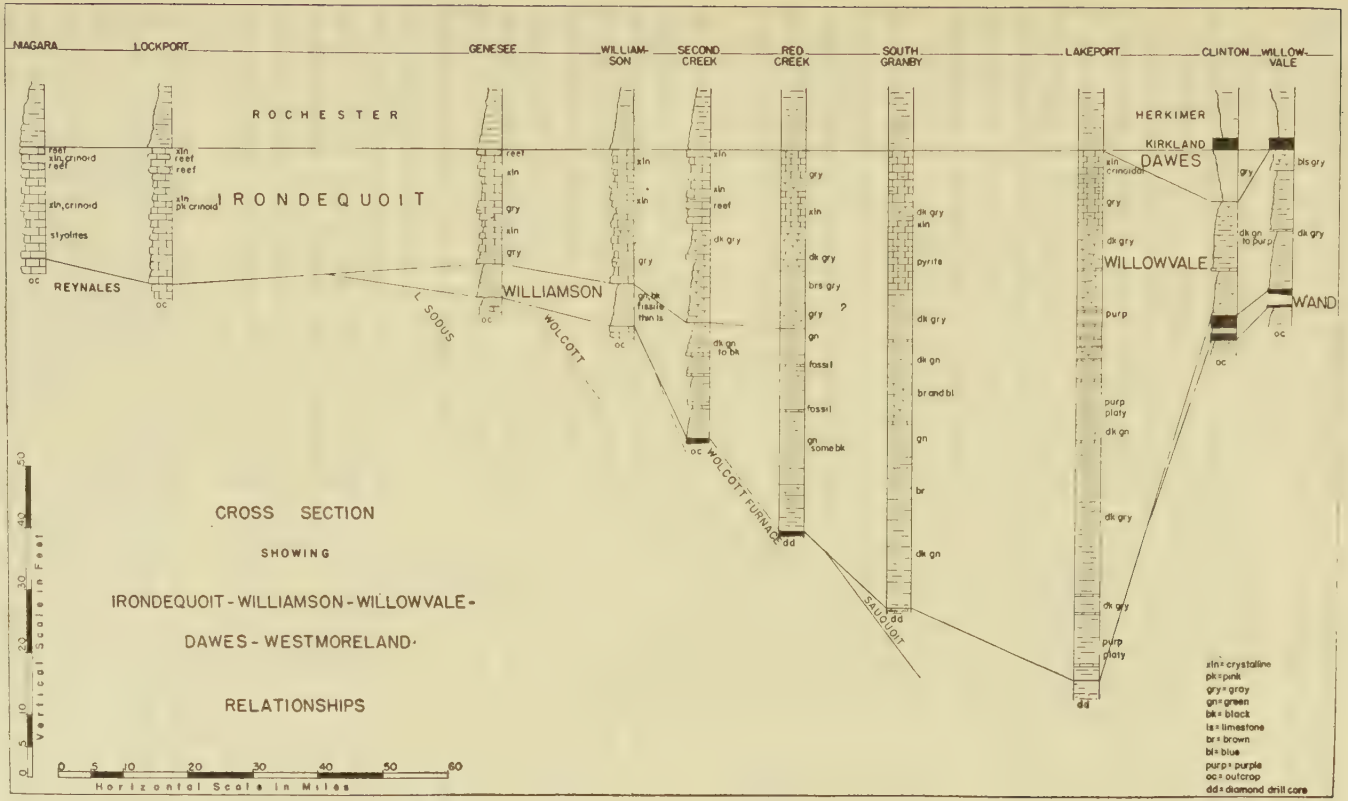

Figure 12 Cross section showing Irondequoit-Williamson-Willowvale-Dawes-Westmoreland relationships

overlying Irondequoit. This is particularly true from central Wayne county eastward.

Fauna. Graptolites are the most characteristic fossil of the Williamson. *Monograptus clintonensis* is by far the dominant species, but *Retiolites venosus* is also present. Graptolites occur more or less abundantly throughout the whole formation. In Monroe and western Wayne counties they are found in greatest number in the fissile black shales. In other places and particularly in eastern Wayne county great tangled masses are often seen covering the bedding planes of the dark green shale layers. The fossils imbedded in the green shale although fewer in number, are less fragmentary. Most of the fossils are flat, sawlike, carbonaceous markings, but occasionally a graptolite is found that has been preserved through calcification.

Brachiopods are second in importance to graptolites. *Sowerbyella transversalis* is the dominant fossil in this class. The shells are so abundant at some horizons that they form limestone layers. Other brachiopods common throughout the formation are *Atrypa reticularis, Spirifer radiatus, Cyrtia meta, Scenidium pyramidale, Bilobites biloba, Chonetes cornutus* and *Coelospira sulcata.*

The other classes of megafossils are as a whole poorly represented in the Williamson. True corals are rare, but at Brewerton *Palaeocyclus rotuloides* is present in considerable numbers. A few fossils of this species have also been found in the outcrops on Little Wolcott creek. The trilobite, *Liocalymene clintoni,* is particularly abundant at Phoenix. In the other outcrops of the formation this fossil is rare.

Most of the ostracods characteristic of the *Mastigobolbina typus* zone are present in the Williamson. A new species of *Dibolbina* is very abundant and ranges throughout the formation. It appears to be confined to the Williamson. A variety of *Beyrichia lakemontensis* is also plentiful. Unlike the *Dibolbina* n. sp. it occurs sparingly in the overlying Irondequoit. *Mastigobolbina punctata* is rare in the lower part of the formation but is common in the upper. *M. trilobata* has never been identified from the lower portion but is present in the upper. *M. typus* itself is confined to the uppermost layers of the Williamson and is rare even in that portion.

Origin. After the deposition of the Sauquoit central and western New York was subjected to a period of erosion of considerable duration. From the work of Ulrich and Bassler ('23, p. 347–49, 374–75) and F. M. Swartz ('34, p. 112–17) it appears that Maryland, Pennsylvania and other areas in the Appalachian region were receiving sediments throughout the time represented by this break in the stratigraphic sequence of New York. The development of thin

basal sandstones and conglomerates as well as the truncation of older formations is accepted as evidence that this unconformity can not possibly be explained by nondeposition or by marine scouring. A relative downward movement of the geosyncline brought marine waters back into New York in the Upper Clinton time.

Based upon the thickness of sediments the path of the Upper Clinton invasion may have been through Madison county. Thence it spread out westward over a low-lying land surface, and eastward it encroached more slowly upon a higher land mass. It is readily recognized that the thickness of sediments is a poor indication of the time consumed in deposition, and the thick section in Madison county compared with that in the western part of the state, may have resulted from the fact that it was relatively near a source of clastics.

An alternative suggestion might be that the marine waters spread out over the whole of western New York and reached as far east as westernmost Oneida county within a brief period of time. Based strictly upon the character of the sediments, this explanation seems plausible. In Niagara county where the source of clastics was far to the east the Irondequoit is almost free from argillaceous material. In Monroe county shale layers appear in the Irondequoit and the argillaceous Williamson is found at its base. In Madison county the pure, crystalline limestones account for a very small part of the entire section (figure 12, p. 81). This theory, however, is not entirely corroborated by fossil evidence. *Beyrichia* aff. *lakemontensis* and *Dibolbina* n. sp. are the only two ostracods which are abundant throughout the Williamson. The former is sparingly found in the Irondequoit and the latter is confined to the Williamson. *Plethobolbina typicalis* is found in the Irondequoit but never in the Williamson. The fossils then point to the fact that the Williamson is probably older than the Irondequoit.

The lack of any good outcrops in the Oneida Lake region makes it extremely difficult to postulate the eastern shore line during the deposition of the Williamson. There is some basis for believing that the Williamson sea extended beyond Clinton and that the Westmoreland iron ore represents the type of sedimentation which was restricted to that locality during the Williamson. The thin shale layers between the oolitic ores yield the two ostracods, *Dibolbina* n. sp. and *Beyrichia* aff. *lakemontensis,* which, as already shown (p. 82), are rather indicative of the Williamson. The same shale, however, which is particularly rich in the ostracods of the *Mastigobolbina typus* zone, yields *Plethobolbina typicalis* which in western New York is not found below the base of the Irondequoit. Sandstones containing the *Mastigobolbina typus* ostracods are found about 15 miles

east of Willowvale. From the occurrences of ostracods it seems possible that the Westmoreland formed in an area not far from the eastern shore and may be partly contemporaneous with the Williamson of western New York.

Conditions within the area receiving the sediments of the Williamson were certainly not uniform. In Monroe and eastern Wayne counties black shale abounding in graptolites but relatively barren of other evidences of past life, formed during a part of the Williamson. Whatever the environment that was responsible for the black shales, it did not extend over the whole area. Eastward dark green, platy, much more fossiliferous shales with thin highly fossiliferous limestones were deposited contemporaneously.

The abundance of pyrite and particularly the presence of thin layers of this mineral in Wayne county indicate that the marine waters carried even in this western area a high concentration of iron. Its occurrence as pyrite rather than as the oxide leads to the conclusion that it was deposited under reducing conditions in contrast with the oxidizing condition which led to the formation of the Westmoreland ore of Oneida county.

Irondequoit Limestone

Definition. Hartnagel ('07, p. 16) named the Irondequoit limestone after the town of Irondequoit in Monroe county. It replaced Hall's ('43, p. 65–67) lithologic designation, "Upper Limestone of Clinton Group."

Extent and lithologic characteristics. The Irondequoit is exposed in the Niagara gorge and in the "Gulf" at Lockport. In this area it is as a whole remarkably uniform for Clinton formations. It is a light gray, coarsely crystalline, crinoidal, pyritic limestone. When unweathered, many of the large crystals have a pinkish cast. Styolitic structures are very common throughout the formation. In a layer immediately above the sharp break between the Irondequoit and the Reynales, Sanford ('39, p. 77–85) records the presence of large pebbles of Reynales limestone embedded in the typical Irondequoit matrix. The only other lithologic feature interrupting the uniformity of the formation is the lenticular, fossiliferous, bluish gray, argillaceous limestone masses which have been called reefs. These always occur in the upper part of the formation and extend up into the basal Rochester. Some of the so-called reefs extend as much as 30 feet along the face of the outcrop and have a position roughly paralleling the bedding planes. The writer has observed many which exceeded four feet in height and Kindle and Taylor ('13) report some with a maximum height of ten feet.

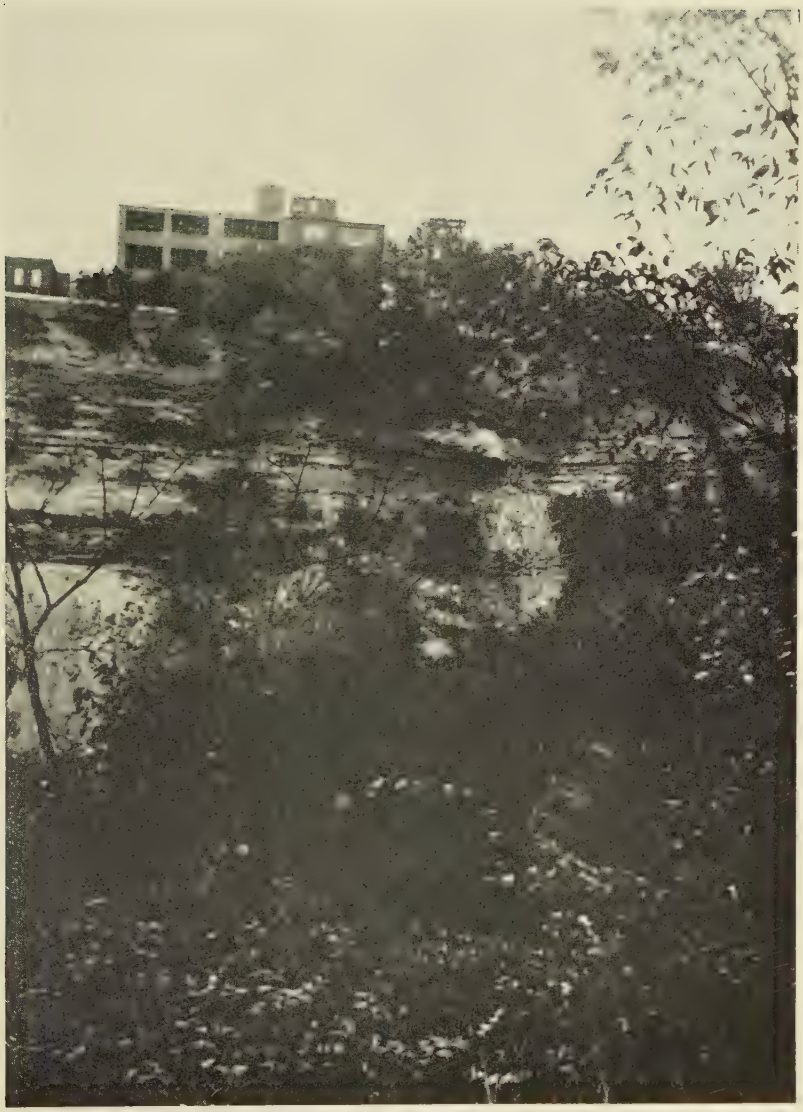

Figure 13 Genesee Gorge. So-called reef in Irondequoit limestone

For all its uniformity in composition the Irondequoit of Niagara county appears to vary considerably in thickness from place to place. Two measured sections at Lockport show a difference of over two feet. It is this irregularity which is probably responsible for the varying thickness reported by geologists: Hall ('43, p. 67) 20 to 25 feet, Grabau ('01, p. 97) 11 feet, Kindle and Taylor ('13) 10 to 15 feet, Alling ('36, p. 189–204) 13.5 feet and Sanford ('39, p. 77–85) 12 feet. The sections measured at Lockport reveal 18 to 20 feet. These two outcrops are about one-eighth of a mile apart. The blue prints of cores put down during the construction of the Barge canal at Lockport and made available to the writer through the courtesy of C. A. Hartnagel show a thickness of 22 feet. It does not seem possible that all these irregularities can be due to errors in measurement. The unconformity at the base of the Irondequoit is very pronounced, and the filling in of the irregularities in the surface upon which the Irondequoit was deposited, is probably responsible for the varying thickness.

In the Genesee gorge (section 5, p. 127) the upper part of the formation has the same coarse crystalline appearance, but lower in the section the limestones become increasingly argillaceous. The argillaceous content reaches a maximum at and immediately above the contact of the Williamson. Thin, dark gray, calcareous shales separate the more massive limestone layers in the lower half of the formation. Pyrite is a prominent mineral occurring throughout the Irondequoit, but is particularly abundant as disseminated cubes in the coarse crystalline layers. The so-called reefs are much in evidence and are restricted to the upper portion (see figure 13, p. 85). The Irondequoit in the Rochester area has a uniform thickness of about 18 feet.

On Second creek (section 14, p. 142) the Irondequoit can be roughly divided into two parts. The lower and thicker part is a crumbly, calcareous, dark gray, fossiliferous shale; the upper contains the crystalline limestone layers with dark gray, calcareous, very fossiliferous shale partings. The two grade into each other through a zone characterized by dark gray argillaceous limestone. The so-called reefs in this area extend from the argillaceous limestone underlying the crystalline limestone into the lowest layers of the Rochester. The total thickness is 27 feet.

In the Red Creek core (section C, p. 178) a further increase in the shale content is noted. In the South Granby (section E, p. 180) and Lakeport (section G, p. 183) cores a line of separation can not be drawn with any degree of accuracy between the Williamson and the Irondequoit, but each of these cores do contain crystalline lime-

stone and dark gray, calcareous shale layers, which possess all the lithologic characteristics of the Irondequoit. The upper crystalline limestone layers in the Lakeport core contain thin stringers or seams of oolitic hematite, and some of the massive crinoid stems so characteristic of the formation are replaced by hematite (see figure 12, p. 81).

To the east of Lakeport it is impossible to assign to the Irondequoit any definite portion of the sections. Rocks occupying the stratigraphic interval are designated as the Willowvale and will be discussed under a separate heading.

The contact of the Irondequoit with the Williamson is everywhere gradational, and it becomes more pronounced eastward, as the lower part of the Irondequoit becomes increasingly argillaceous. To the west of Monroe county the Irondequoit rests unconformably upon the upper eroded surface of the Reynales. In western New York where the outcrops are available the contact of the Irondequoit with the overlying Rochester is marked by a distinct break in lithology. No evidence, however, has ever been found of any unconformity separating the two formations. In Wayne county and to the west the so-called reefs are found in both the Rochester and the Irondequoit. This would seem to point to a close relationship of the two formations. In the area to the east of Wayne county where the contact is not exposed, the cores obtained show a distinct break in lithology. The uppermost Irondequoit is always a crystalline, crinoidal limestone upon which rests the gray shales of the Rochester.

Fauna. The Irondequoit really possesses three distinct faunas, one characteristic of the crystalline limestone layers, another developed in the thin shales separating the crystalline limestone layers and associated with the so-called reefs, and the third found in the lower, shaly portion of the Irondequoit of Wayne and Cayuga counties.

Many of the limestones are made up almost exclusively of crinoid stems. Fossils associated with the crinoid stems are relatively few in number and consist of cup corals and brachiopods. The most common species of brachiopods are *Atrypa reticularis, Leptaena rhomboidalis, Whitfieldella cylindrica, W. intermedia* and *Spirifer radiatus.*

The thin shales between the massive limestones and the so-called reefs of Niagara, Orleans, Monroe and Wayne counties yield a much larger assemblage. Some of the more common are *Schuchertella subplana, Orthis tenuidens, Dalmanella elegantula, Sowerbyella transversalis, Dictyonella coralifera, Spirifer radiatus, S. niagarensis, S. sulcata, Atrypa reticularis, A. rugosa, Atrypina disparilis, Whitfieldella nitida* and *W. intermedia.* Bryozoans are very abundant.

The most characteristic are *Eridotrypa striata, Rhinopora verrucosa, Semicoscinium tenuiceps* and *Phylloporina asperato striata.* The trilobite, *Dalmanites limulurus,* and the cephalopod, *Dawsonoceras annulatum,* are two other important fossils.

The fauna of the lower or shale phase of the Irondequoit in Wayne and Cayuga counties is also dominated by brachiopods but by quite a different assemblage. In these strata *Whitfieldella intermedia, W. cylindrica, Chlorinda fornicata, Orthis tenuidens, Scenidium pyramidale, Spirifer radiatus, Cyrtia meta* and *Sowerbyella transversalis* are the characteristic and most abundant forms. Trilobites are common and include *Liocalymene clintoni, Encrinurus ornatus* and *Phacops trisulcatus.*

From the above list of common species the megafauna of the Irondequoit shows a transition from the typical Williamson to the Rochester. These forms associated with the shaly portion are very similar to those found in the Williamson, whereas the fossils in the thin shale partings in the upper part of the Irondequoit closely resemble the Rochester assemblage.

The microfauna of the Irondequoit includes all the forms diagnostic of the *Mastigobolbina typus* zone with the exception of *Dibolbina* n. sp. A list of the more common species includes *M. typus, M. punctata, M. trilobata, Plethobolbina typicalis* and *Beyrichia* aff. *lakemontensis.* The microfauna then shows the close relationship existing between the Irondequoit and the Williamson.

Origin. As already pointed out (p. 82) the Irondequoit was probably deposited in a continuation of the same sea in which the Williamson formed. In Irondequoit time the sea continued to spread westward, and in so doing it reached into regions where argillaceous material was less accessible. Clear crystalline limestones of Niagara, Orleans and western Monroe counties are the proof for this assumption. Eastward, still considerable argillaceous material was being carried into the waters from the land mass. With the advance of the sea this source of argillaceous material, however, was moved farther and farther to the east. This probably explains the formation of the clear crystalline crinoidal limestones in the uppermost part of the Irondequoit as far east as Lakeport.

There is some evidence which seems to point to a minor recession of the strandline westward into Madison and Oneida counties late in Irondequoit times. The position of the Dawes sandstone at Clinton shows that a portion of Oneida county was under continental or beach influences while the upper Irondequoit was still forming in western New York. The rapid thinning of the rocks (figure 12,

p. 81) carrying the forms typical of the *M. typus* zone may in part be due to erosion during this minor recession. Certainly to the west there is no indication of a removal of the sea at the close of the Irondequoit.

The vast increase in numbers and the greater variety of the megascopic fossils of the Irondequoit indicates that conditions changed considerably during the Irondequoit from those prevailing in Williamson time. Graptolite-bearing shales could no longer form. On the other hand the crumbly, dark gray lower shale facies of the Irondequoit provided an ecology suitable to most of the other megafossils, which had thrived throughout the Williamson. Further changes in the late Irondequoit produced an environment which was apparently conducive to a much greater number of individual species. So alike are the fauna and lithology of the shale breaks representing the deposits of the late Irondequoit and the rocks of the early Rochester that they obviously formed under similar conditions and derived their clastics from the same source. Of course some of the dissimilarity in fossil content may be due to the difference in age of the rock of the Lower and Upper Irondequoit, but certainly not all.

The origin of the so-called reefs in the upper part of the Irondequoit in western New York has not been adequately explained. Sarle ('01, p. 81–82), studying these lenticular masses in the Rochester area, came to the conclusion that they were formed by certain bryozoans. The writer ('40, p. 36) observed these same bryozoans in the reefs on Second creek and accepted Sarle's explanation. Bryozoans may have aided greatly in their formation in many areas, but more extensive observation leads to the conclusion that they could not have been wholly responsible. Some reefs have no bryozoans whatsoever. Many in the Lockport and Niagara sections are composed largely of crinoid stems and brachiopods. A study of the fossils from the reefs in this area shows that they possess the same species common to the thin shales of the upper Irondequoit of Wayne and Cayuga counties. It may be suggested that these lenticular masses were formed by current action that swirled the light argillaceous, organic material into piles and mounds on the ocean floor, and that the fossils found in these mounds originally lived under conditions similar to those which resulted in the deposition of the shale layers to the east.

Westmoreland Iron Ore

Definition. The Westmoreland is introduced as a designation for the oolitic iron ore of Smyth ('95, p. 104) and Newland and Hartnagel ('08 p. 26–27 and p. 61–64). The type locality is on a tribu-

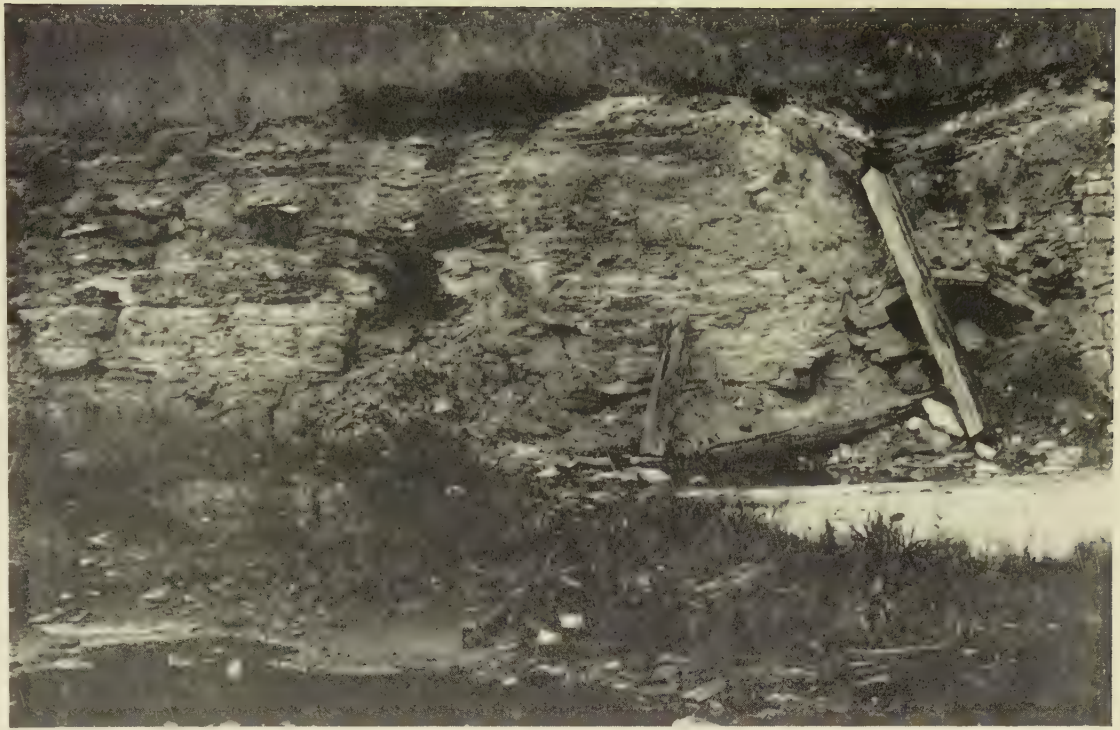

Figure 14 Clinton, New York. Old Borst iron ore mine

tary of Oriskany creek approximately one-half mile east of the hamlet of Lairdsville in the town of Westmoreland, Oneida county. Its best exposure are in the ore mines within the limits of the village of Clinton. The formation is overlain by the Willowvale and underlain by the Sauquoit.

Chadwick ('18, p. 346) incorrectly correlated the Westmoreland with the ore occurring at Verona Station. At Clinton the Westmoreland is underlain by the Sauquoit. At Verona Station the hematite bearing rock is overlain by the Sauquoit. Hence the Verona iron ore of Chadwick which is designated as the Wolcott Furnace iron ore in this report (p. 70) can not be used as a name for the oolitic ore at Clinton and vicinity.

Extent and lithologic characteristics. The Westmoreland has been extensively mined in the vicinity of Clinton in the past (Newland and Hartnagel, '08, p. 58–67) and is still being mined to a certain extent. At first the ore was removed by stripping off the overburden. When the thickness of the overlying shale became too great, underground methods were employed. Many of the old open pits are so badly weathered that it is impossible to obtain rock in place. Some still offer an opportunity to study the Willowvale shale overlying the ore, and at the old Borst mine the upper surface of the Westmoreland remains visible (figure 14, p. 91).

The Westmoreland at its type locality is approximately 18 inches thick. The ore is the oolitic type and appears to have a high iron content. The formation is medium to thin bedded with shale breaks between the layers. There is no evidence of any gradation of the hematite upward into the overlying or downward into the underlying rock. A short distance to the north along the south side of Deans Creek valley the ore becomes argillaceous with a prominent shale parting about seven inches from the base. At this outcrop the ore is only 16 inches thick. The Westmoreland has not been identified any farther to the west.

The Westmoreland reaches its maximum development at Clinton. Here it measures from 30 inches to over three feet. Most of the differences in thickness is due to a prominent shale layer which varies from a thin parting to over a foot in thickness. This shale occupies a position about two feet from the top of the formation. The two hematitic portions of the Westmoreland, separated by the shale, have the same characteristics. Both are oolitic and are high in iron. The shale parting closely resembles the overlying Willowvale. It is dark in color, highly fossiliferous and at some place possesses a thin argillaceous limestone.

Eastward from Clinton the ore outcrops in several places along the road between Clinton and Washington Mills. An accurate estimate of its thickness could not be obtained. Along this same road are various open cuts. Newland and Hartnagel ('08, p. 61) report that the thickness in these cuts ranges from 18 to 24 inches. At Willowvale the ore is poorly exposed but it probably is about two feet in thickness. East of Willowvale the horizon can be traced at least as far as the Herkimer-Oneida county line (Newland and Hartnagel, '08, p. 59–60).

Fauna. The Westmoreland is not a fossiliferous iron ore and if it were not for the shale layers, found within the formation, it would be impossible to tell much concerning its age. Fortunately fossils are found in the shales, and these show a close relationship with the forms in the overlying Willowvale. Graptolites are common and are represented by *Monograptus clintonensis* and *Retiolites venosus.* The coral *Palaeocyclus rotuloides,* is abundant. *Chonetes cornutus, Dalmanella elegantula, Leptaena rhomboidalis* and *Spirifer radiatus* are the most common brachiopods. The trilobites, *Dalmanites limulurus* var. *lunatus* and *Liocalymene clintoni,* occur in considerable numbers. Ostracods of the *Mastigobolbina typus* zone are well represented by *Plethobolbina typicalis, M. typus* and *M. trilobata.* A few individual specimens of *Dibolbina* n. sp. and *Beyrichia* aff. *lakemontensis* have also been collected, but they are comparatively rare.

Origin. In its origin the Westmoreland is certainly connected with the deposition of the Williamson and the Irondequoit (p. 83). It apparently formed in a zone to the west in which the Williamson and possibly even some parts of the Irondequoit were forming. To the east beach conditions prevailed. Thus the Westmoreland appears to be directly connected with the eastward advance of the Upper Clinton sea.

Willowvale Shale

Definition. The Willowvale is introduced as a designation for those rocks which occupy a position between the Westmoreland (oolitic iron ore) and the Kirkland (red flux iron ore). The type locality of the Willowvale is on a small tributary flowing eastward into Sauquoit creek at the village of Willowvale (section 34, p. 171). The shale is well exposed underneath the Kirkland which forms the cap rock of a small falls at the top of a steep ravine or glen approximately 2000 feet west of the main village street.

Extent and lithologic characteristics. At the type locality the Willowvale (section 34, p. 171) is about 22 feet thick and consists

of a uniform, dark gray to purple, thin-bedded shale which is highly fossiliferous. The upper three feet of the formation is more calcareous than the underlying rock and has a slightly different color being a bluish gray. This portion is very fossiliferous but the specimens are fragmentary and appear to have been crushed and broken. There are a few thin limestones, and most of these are composed almost exclusively of the coral, *Palaeocyclus.*

A few miles to the west at Clinton (section 33, p. 169) the Willowvale exhibits the same lithology and has about the same thickness. At this point however the Dawes sandstone occupies a position between the top of the Willowvale and the base of the Kirkland. Between Clinton and Lakeport, a distance of 21 miles, the Willowvale merges with the Irondequoit and Williamson formations. The deposits have been previously discussed (see figure 12, p. 81).

To the east of the type section the formation extends into Herkimer county. It finally fades into and interfingers with a beach sandstone.

Both the lower and upper contacts of the Willowvale are sharp and well defined. No stringers of hematite reach upward into the formation from the underlying Westmoreland. Even where the ore is argillaceous there appears to be no gradation. As abrupt as the change is, no evidence of an unconformity was observed. The upper limits are even more clearly marked, and the Willowvale is separated from the overlying formations by an erosional unconformity.

Fauna. The Willowvale has a rich and varied fauna. The graptolites, *Monograptus clintonensis* and *Retiolites venosus,* which are so characteristic of the Williamson, occur in considerable numbers throughout the Willowvale. A few dendroid graptolites are also represented. True corals are much in evidence, and some layers are composed of *Palaeocyclus rotuloides. Chaetetes lycoperdon* is another common species. The bryozoans are a very prominent class. *Ceramopora imbricata, Rhinopora verrucosa, Eridotrypa striata* and *Chasmatopora asperatostriata* are among the more dominant species. Brachiopods are present in great numbers. A partial list of the common species includes *Coelospira sulcata, Dalmanella elegantula, Sowerbyella transversalis, Chonetes cornutus, Bilobites biloba, Atrypa reticularis, Camarotoechia neglecta, Schuchertella subplana, S. tenuis, Stropheodonta profunda, Spirifer radiatus* and *S. niagarensis.* The pelecypods are particularly abundant throughout the formation. *Pterinea emacerate, Leptodesma rhomboidea* and *Cuneamya alveata* are three of the most common forms. The cephalopod, *Dawsonoceras annulatum,* and the trilobites, *Liocalymene clintoni* and *Dalmanites limulurus,* are found in considerable numbers.

The microfauna is equally well developed in the Willowvale. The ostracods include *Plethobolbina typicalis, Beyrichia* aff. *lakemontensis, Mastigobolbina typus, M. trilobata* and *M. punctata.* The above listed forms are found in every outcrop of the formation. *Dibolbina n. sp.* is rare, but it has been found in the basal portion in the outcrops of the formation at the village of Clinton.

It will be noted that the species common in the Willowvale include most of the fossils which are characteristic of the Williamson and the various parts and facies of the Irondequoit farther to the west. As a whole the abundance of pelecypods is the only characteristic addition, and all of those species listed have been sparingly found in the shaly phase of the Irondequoit in Wayne and Cayuga counties.

Most of the fossils in the Willowvale are preserved as natural casts. In the upper three feet of the formation at Willowvale the fossils are fragmentary and hard to determine specifically. Throughout the rest of the formation the fossils are easily identified.

Origin. The Willowvale was unquestionably deposited in the same Upper Clinton sea that was responsible for the Williamson and the Irondequoit. The actual conditions of sedimentation must have been quite different from those existing where the other two formations were being deposited. Although it is a shale its lithology is not like that of the Williamson. It is thin-bedded but neither platy nor fissile. The thin beds are not parallel as in the Williamson, and a large part of the Willowvale appears to be great jumbled masses of thinly laminated argillaceous material. It is dark gray to purple in color in contrast with the dark green to black. Furthermore it is not like the calcareous phase of the Irondequoit. It cleaves readily along the bedding planes and does not possess a crumbly, massive, calcareous nature, nor upon weathering does it become a sticky, yellowish clay so characteristic of the shaly phase of the Irondequoit. The only rock of western New York, which closely compares in lithology with the Willowvale is the thin shale layers between the crystalline limestones of the Irondequoit in Wayne county.

The fossils point to a unique condition or set of conditions. Graptolites are found intimately associated with corals, bryozoans, brachiopods, trilobites and pelecypods. In no other formation is there such a close relationship of distinctly different classes of fossils. The explanation of such an occurrence on the basis of ecology is extremely difficult. It may be that conditions alternated so rapidly in the area that the effect produced is misleading in that the fossils appear to have lived in the same environment whereas each actually thrived in surroundings particularly suited to the individuals. It is also pos-

Figure 15 Clinton, New York. Dawes Quarry creek showing Herkimer, Kirkland and Dawes

sible that waves, currents and other forces at work within the sea may have mingled the forms requiring dissimilar environments. This may be an explanation for the peculiar bedding of the Willowvale.

Before the close of Irondequoit deposition in western New York it seems highly probable that marine conditions had already withdrawn from the eastern half of Oneida county, and that this area was undergoing active erosion. The effect of this period on the Willowvale shale is shown by the wavy upper surface upon which rests the Kirkland iron ore near the village of Willowvale. The fragmentary condition of the fossils in the upper part of the Willowvale at the type locality may be due to erosion and weathering. At Clinton the upper surface is very irregular, but there is no mass of broken and crushed fossils. The cross-bedded Dawes sandstone, however, occupies a position between the Willowvale and the Kirkland, and such a condition is in itself indicative of an unconformity. The rapid thinning of the beds westward away from the source of the clastics is still another strong argument in support of a period of erosion (figure 12, p. 81).

Dawes Sandstone

Definition. The Dawes sandstone is introduced as a designation for the light gray, slightly calcareous sandstone which underlies the Kirkland iron ore and overlies the Willowvale shale. The type locality is on a small stream locally known as Dawes Quarry creek flowing west into Oriskany valley within the limits of the village of Clinton. Previously this formation has been designated as the calcareous sandstone by Smyth ('95, p. 104) and by Ulrich and Bassler ('23, p. 346) as Bed No. 7 Upper Clinton.

Extent and lithologic characteristics: The Dawes sandstone measures approximately eight feet at the type locality (section 33, p 169). It consists of a very cross-bedded, light gray, slightly calcareous, unfossiliferous sandstone (see figure 15, p. 97). The sand grains range from very fine to coarse according to the Wentworth scale. In the basal portion are a few thin layers of arenaceous shales.

The Dawes sandstone has a very limited extent. It is not known to the west of College Hill creek on the west side of the Oriskany valley nor to the east of Dawes Quarry creek. If the Dawes could be included in another formation as a member, it would be highly desirable. An unconformity at the top and base of the formation together with the total absence of fossils makes it impossible to relate it to either the overlying or underlying formation.

Origin. The origin of the Dawes sandstone may be connected with the unconformity at the top of the Willowvale. It may have formed

as a local continental or semicontinental sandstone near the margin of the receding Upper Clinton sea. Possibly it represents a small delta deposit. Its lack of fossils and any semblance of uniform bedding tends to the conclusion that it is not a normal marine sandstone.

Rochester Shale

Definition. The Rochester was first named by Hall ('39, p. 290) for the typical exposures of this formation in the Genesee gorge. Later ('43, p. 80–84) he discarded the term, Rochester, and proposed to designate the strata as the Niagara shale. His reason for this shift was based on his conception of the Niagara group, which he believed should include two formations in western New York, the Niagara limestone (Lockport dolomite) and the Niagara shale (Rochester shale). Clarke and Schuchert ('99, p. 874–78) revived the title, Rochester shale, with its original meaning.

Extent and lithologic characteristics. The Rochester has a greater thickness and is better exposed than any other Clinton formation. From Niagara county on the west to Onondaga county on the east streams flowing northward from the area underlain by the more resistant Lockport dolomite, cut into the softer Rochester. Many of the outcrops thus uncovered, it is true, are fragmentary, but by piecing these together it is not difficult to obtain a fairly inclusive section within the radius of a few miles of any given point.

As a whole the Rochester is a dark bluish to brownish gray, calcareous, fossiliferous shale with argillaceous limestone layers. It changes somewhat from outcrop to outcrop, but it retains its characteristic color and its highly fossiliferous content throughout western New York. For this reason it has been correctly recognized as an important unit for more than a century.

In the Niagara gorge (section 1, p. 120) the Rochester is about 75 feet thick and can be roughly divided into two parts. The lower part is a bluish gray shale with numerous thin limestone layers. The calcareous shale itself is thin-bedded and very fossiliferous. The lower 10 feet of this division contains the famous crinoid horizon, but as a whole it is not so fossiliferous as the rock immediately overlying it. The upper four feet of this portion is a very calcareous shale with numerous, very thin limestone layers. Many of these limestones are made up almost exclusively of bryozoans. The upper half of the formation is less fossiliferous and tends to be brownish gray in color. Limestone layers are much less frequent, and the shale as a whole is not so calcareous. The upper 10 feet is more massive bedded than any other part of the Rochester and tests show that it is dolomitic as well as calcareous.

The outcrops in the vicinity of Lockport (section 2, p. 123) show that the Rochester has increased slightly in thickness (figure 16, p. 102). The lower 50 feet of the formation is a dark bluish gray shale with numerous limestone layers, most of which are argillaceous, but some are crystalline. The lower 15 feet are sparingly fossiliferous, but the rest of this portion of the Rochester abounds in fossils. At the top of this lower division are five feet of strata very rich in bryozoans. Ostracods are also very abundant and a few thin layers consist of little but their remains. The upper 25 feet of the formation is brownish gray with argillaceous limestones. This portion is dolomitic especially near the contact with the Lockport. It is quite possible that the dolomitic character of the shale was mistaken by some of the earlier geologists as indicating a siliceous content. The shale does contain some sand grains of silt size, but as a whole it is no more siliceous than layers occurring lower in the formation.

The Rochester at its type locality is about 85 feet thick. Except for the basal 10 feet which is brownish gray, it is dark bluish gray in color. The lower few feet and the upper 15 feet are relatively unfossiliferous, but the rest contains an abundance of fossils. In all but the lower 10 feet limestone layers are plentiful. The lower 25 to 30 feet of the formation is a weak shale, which upon being exposed quickly disintegrates into a blue to brown clay. The upper 20 to 25 feet is more massive-bedded and more resistant. Like the upper part of the Rochester to the west it is slightly dolomitic. Hartnagel ('07, p. 18) states that this portion of the formation was formerly quarried for building stone. Chadwick ('18, p. 360) gave it a separate designation, the Gates limestone.

To the east the Rochester increases rapidly in thickness (figure 16, p. 102) and in the vicinity of North Victory, Cayuga county, it reaches a maximum of about 140 feet along the line of outcrop. To the south in the vicinity of Clyde and Geneva it attains even a greater thickness as shown by well records. For a full discussion the reader is referred to an earlier publication (Gillette, '40, p. 88–94).

As far east as Wolcott the Rochester retains most of its lithologic characteristics. The lower 35 to 40 feet is a dark gray, calcareous shale with a few limestone layers. Except for the lower three feet, it is fossiliferous. This part is followed by a central portion which is highly calcareous but sparingly fossiliferous. It is dark gray to brownish gray in color. Limestone layers are particularly abundant at the top and are so resistant that they are often found forming the cap rock for small waterfalls. While it is similar in its more resistant character to the uppermost Rochester in Niagara and Monroe counties, it differs by having a very low magnesium content. The upper 35

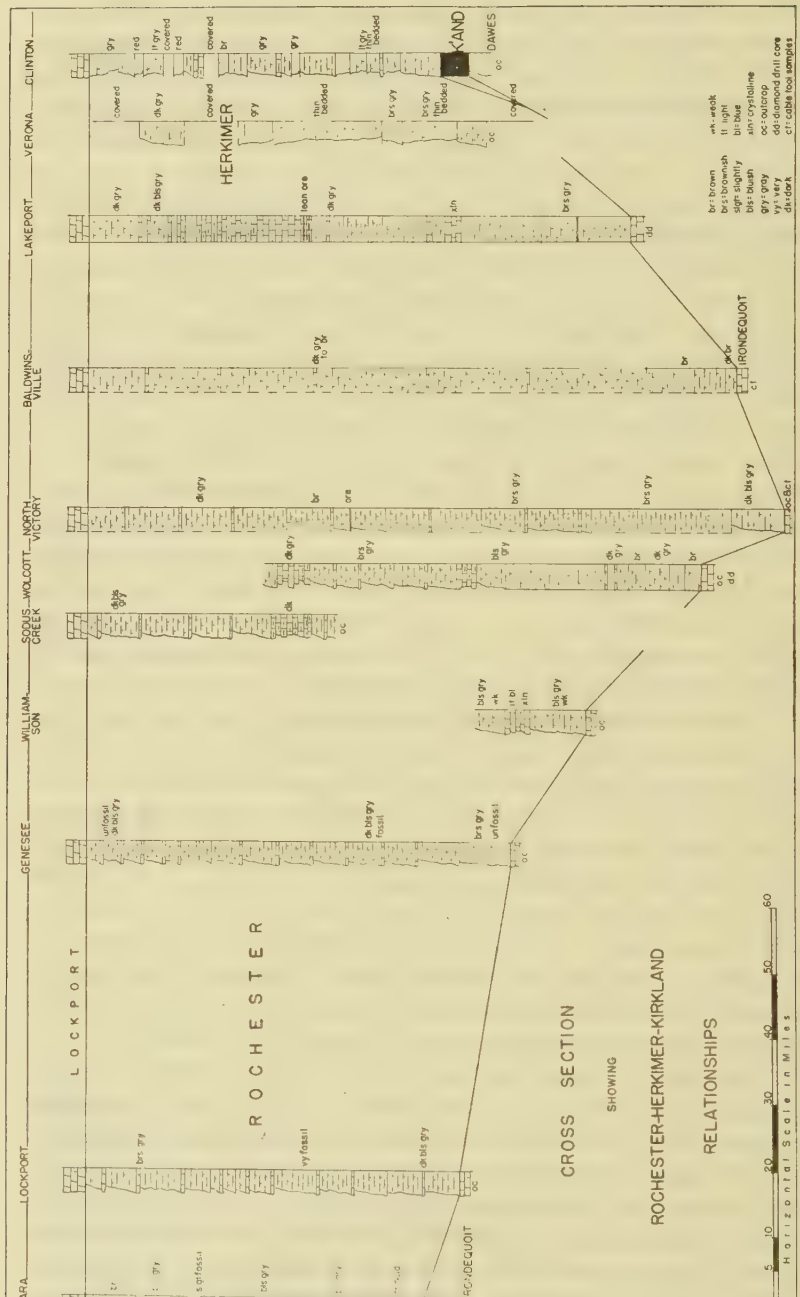

Figure 16 Cross section showing Rochester-Herkimer-Kirkland relationships.

feet (section 15, p. 146) of the formation is a bluish gray, calcareous shale with fewer limestone layers. This part is again highly fossiliferous, and the fossil bearing rock extends upward to the very contact of the Lockport. The upper five feet contain a few dolomitic layers.

The first real change in lithology is noted in the outcrops in the vicinity of North Victory, Cayuga county (section 22, p. 156). The lower 11 feet of the formation are the same dark brownish shale so characteristic of the Rochester of Wayne county. Samples from a cable tool well not far from North Victory show thin sandstone layers beginning to appear above these basal few feet. These thin sandstone layers are exposed in a fragmentary section located about 38 feet above the base of the formation. The sandstones are interbedded with typical brownish gray, highly fossiliferous, calcareous shales. The upper 80 feet of the formation contain no sandstone layers. A thin, lean iron ore, occupying a position 55 feet from the top of the formation, deserves special notice. This is the farthest west of any indication of concentration of hematite in the Rochester.

Between North Victory and Lakeport the outcrops of the Rochester are fragmentary. From gas well records in the vicinity of Baldwinsville it is possible to determine the thickness of the formation as 130 feet (figure 16, p. 102). The samples which were available were so widely spaced that the lithology could not be accurately determined. The diamond drill core at South Granby (section E, p. 180) in the same general area, shows that the lower 18 feet of the formation are a brownish gray, calcareous shale which is slightly sandy at the contact of the Irondequoit and contains a thin sandstone layer about 18 feet above the base.

In the Lakeport core (section G, p. 183) the lower part of the Rochester begins to assume a lithology approaching that of the Herkimer. The lower 65 to 70 feet of the formation is brownish gray in color with thin sandstone layers. The shale itself is less calcareous and is slightly sandy. The sandy character of the shale reaches downward to within a few feet of the base of the formation. Except in the basal few feet limestone layers are rare. The upper 45 to 50 feet of the formation more closely resemble the typical Rochester and is a dark bluish gray, calcareous shale. Limestone layers are abundant, and they increase downward. In fact at the base of this portion of the formation argillaceous limestones dominate the section. Immediately beneath these argillaceous limestones is a coarsely crystalline limestone with a few hematitic stringers.

The Rochester rests on the Irondequoit throughout western New York. The contact is always sharp and easily definable. The two formations always appear to be perfectly conformable, and there

is no evidence of any erosion between the deposition of the Irondequoit and the Rochester.

The Rochester is overlain by the Lockport dolomite and the upper limit is also easily determined. Whether an unconformity exists between the Rochester and the Lockport, particularly from the Genesee gorge westward, has been a source of controversy. Hall ('43, p. 106) and Hartnagel ('07, p. 22) agreed that the Rochester graded upward into the Lockport. Ulrich ('11, p. 28) found formations to the west which he considered to be intermediate in age between the Rochester and the Lockport. In order to make a place for these formations an unconformity of considerable magnitude was postulated between the Rochester and the Lockport of western New York. Grabau ('13, p. 470–71) claimed that such an unconformity was wholly unwarranted and that the Rochester of western New York passed upward into the Lockport without a break. Schuchert ('14, p. 277–320) gave a description of the outcropping sections in western New York and Ontario. Due largely to the westward thinning of the Rochester he believed that there was an unconformity between the Rochester and the Lockport which increased in magnitude especially west of the Niagara Gorge section. Chadwick ('18, p. 355–65) considered that there was evidence of an unconformity between the upper part of the Rochester which he called the Gates limestone and the overlying Lockport. He used this break as the upper boundary for his Eontaric.

In spite of all that has been written the writer believes that something can still be profitably said concerning the Rochester and Lockport boundary. No one can possibly place an unconformity between the Rochester and Lockport on Sodus creek (section 15, p. 146). At that place the Rochester grades into the Lockport through a transition zone at least two feet six inches thick. Because of construction the contact can not be studied in the Genesee gorge. In the Barge Canal section in the town of Gates (section 4, p. 126) the upper surface of the Rochester is slightly undulating as close observation reveals. There is, however, no trace of any truncation of bedding planes such as must accompany indisputable evidence of erosion. The bedding planes all parallel the upper surface. At Lockport there is most assuredly an interbedding of dolomitic layers with the typical Rochester shale. This transition zone is 18 inches thick and overlain by the DeCew member of the Lockport with its so-called enterolithic structure (Grabau '13, p. 470–71). The base of the DeCew in contact with the transition zone is slightly irregular but the real undulating surface occurs at the top of the DeCew immediately under the Gasport member. No one has even suggested placing an uncon-

formity at this point. In the Niagara section there does not appear to be any transition zone, and the upper surface of the Rochester is wavy. Again there is little if any evidence of a truncation of bedding. The upper surface of the DeCew beds is again much more irregular than the Rochester. In the Genesee gorge, Lockport and Niagara Gorge sections the upper part of the Rochester is dolomitic and in this respect is transitional between the calcareous shale below and the dolomite above.

A study of the contact reveals that the basis for an unconformity must rest wholly and entirely upon the westward thinning of the Rochester shale. This may be a rather weak argument. In the Geneva gas field about 22 miles south of the outcrop on Sodus creek the Rochester is 155 feet thick. Certainly there is no evidence that more than 20 feet of sediments have been eroded from the Sodus creek section. Furthermore the Rochester continues to thicken east of Sodus creek, and one would certainly expect an unconformity and not a transition zone if erosion is to explain the westward thinning.

Fauna. The fauna of the Rochester is the largest and by far the most diversified of all the Clinton formations. The lithology of the Rochester is such that perfectly preserved specimens can be easily broken from the fresh rock. Furthermore the fossils being more resistant than the inclosing shale are often found covering the outcrops, where they were left as the rock disintegrated. Because the Rochester is so fossiliferous and the specimens so well preserved, many famous collections have been made and described in the literature. The formation differs so greatly in lithology from the rocks underlying and overlying, that even the earliest reports on the fauna appear to be reliable.

The complete list of fossils collected at each locality from the Rochester is shown in the faunal tables (p. 18–21). Even these lists of fossils which include some rare as well as the common forms do not pretend to represent the complete Rochester fauna, but only those forms which were collected and identified by the writer.

Brachiopods are the dominant class of fossils. The most characteristic forms are *Dalmanella elegantula, Sowerbyella transversalis, Spirifer radiatus, S. niagarensis, Stropheodonta profunda, Schuchertella tenuis, Atrypa reticularis, A. rugosa, Leptaena rhomboidalis, Whitfieldella nitida, Camarotoechia neglecta, Rhipidomella hybrida* and *Dictyonella corallifera.* West of Wayne county bryozoans abound in the rocks of this formation. Bassler ('06) made a special study of these fossils and listed 84 species. In Wayne county and to the east bryozoans are less common. The three species most common are

Mesotrypa nummiformis, *Ceramopora imbricata* and *Chasmatopora asperatostriata*. In some parts of the formation trilobites are plentiful. *Dalmanites limulurus*, *Homalonotus delphinocephalus* and *Arctinurus nereus* are characteristic. Cephalopods are also common and *Dawsonoceras annulatum* was found in all but four outcrops. Pelecypods, gastropods, conularids sporadically occur in considerable numbers. Ostracods are well represented in the Rochester. A large number of species, many of which have never been described, are present. The outcrops in the vicinity of Lockport abound in this class of fossil. Only four species, however, appear to be common in sufficient numbers in widely separated outcrops to be of value in stratigraphic correlation. These are *Paraechmina spinosa*, *P. postica*, *Dizygopleura proutyi* and *Beyrichia veronica*.

Origin. Toward the close of the Irondequoit sedimentation there appears to have been a positive movement of the land mass to the east, the culmination of which brought to a close the clastic free Irondequoit deposition. This uplift not only caused the strand line to migrate westward in Rochester time, but the resulting higher land surface furnished a source for the argillaceous and clastic material which accounts for a large part of the Rochester. The argillaceous character of the Rochester is evident and needs no proof. The movement of the strand line westward is shown by the regressive overlapping of the nonclastic Irondequoit and the argillaceous Willowvale by the marine, beach and semicontinental sandstones of the Herkimer.

The source of most, if not all, of the clastics of the Rochester was probably the land mass to the east. This is shown by the indisputable fact that the sediments become coarser eastward. Furthermore the thickness of the Rochester diminishes westward from the center of accumulation. M. Y. Williams ('19, figure 11, p. 22) and Schuchert ('14, p. 277–320) show that this thinning continues in Ontario and that the Rochester pinches out near Kelso. This may suggest that there was no source of argillaceous material to the immediate west or north.

As already pointed out (p. 104) several eminent geologists have contended that the thinning of the Rochester westward is due to erosion. The writer has never visited the outcrops in Ontario, Canada, and some of the thinning is probably erosional. No great amount of the reduction in thickness westward within New York State, however, can be ascribed to this source (see p. 105).

From the nature of the sediments comprising the Rochester in the Lakeport core, it would seem that the land mass to the east became worn down toward the middle of the interval represented

by the deposition of that formation. Sandstones and sandy shales are confined to the lower half of the formation. This is also apparent to a lesser degree in the outcrops at Verona. The wearing down of the land mass and the filling in of that portion of the basin nearest the shore forced the sea westward toward the close of the Rochester. This is shown by the presence of continental sandstones in the upper portion of the Herkimer at Clinton and by the decided undulating and truncated upper surface of the Herkimer in Oneida county. The gradual process of wearing down and leveling of the land surface removed the source of argillaceous and clastic material. This helped set the stage for the formation of the extensive Lockport dolomite and other Niagaran limestone to the west and north.

Conditions were not uniform within the Rochester sea and the environment resulting from these various conditions undoubtedly had a great deal to do with the present distribution of the fossils. For example, intervals suitable to the growth and preservation of bryozoans were more frequent and of longer duration in Monroe, Orleans and Niagara counties than farther to the east. At times, particularly in Niagara county, the bryozoans were so plentiful that their remains formed the thin limestone layers. In Cayuga county and to the east they were able to exist as evidenced by the scattered fossils, but did not thrive in such numbers. The crinoid horizon in the Niagara gorge, the ostracod layers at Lockport, the *Whitfieldella nitida* layers of the Wolcott gorge, all appear to be the result of conditions which were suitable to the growth and preservation of individual classes and species. As a whole the Rochester seems to have been a time suited to a great variety of invertebrate life.

Kirkland Iron Ore

Definition. The Kirkland iron ore was named by Chadwick ('18, p. 349). It superseded the upper iron ore of Vanuxem ('42, p. 79–90) and the red flux iron ore of Smyth ('95, p. 104) and Newland and Hartnagel ('08, p. 27, 58–67).

Extent and lithologic characteristics. The Kirkland at Clinton (section 33, p. 169) is a fossiliferous hematic limestone. The concentration of hematite is low in comparison with the other iron ores of the Clinton. Much of the limestone is only barely stained although portions show a relatively high concentration. The fossils show all degrees of replacement varying from complete replacement to a thin coating of hematite. Some of the layers are crystalline with few fossils. In these latter the outer surfaces of some of the coarser crystals of calcite appear to be replaced; others seem to be only

stained a red color. A few siderite crystals were found. Certain layers are slightly sandy, but as a whole the formation is remarkably free of quartz, considering the fact that it is both underlain and overlain by a sandstone.

The Kirkland is extremely variable. On Dawes Quarry creek (section 33, p. 169) it measures about five and one-half feet. Across Oriskany valley on College Hill creek it is slightly over five feet, and there is a remarkable increase in the amount of wholly unreplaced limestone. At Willowvale (section 34, p. 171) it is roughly 54 inches thick. Here in spite of the fact that it contains argillaceous material, it shows a higher iron content and is more nearly comparable in general appearance with the fossiliferous iron ores of the Lower Clinton.

The lower limit of the formation is sharp. It is separated from the Dawes sandstone at Clinton and the Willowvale shale at Willowvale by an unconformity. In some spots the Dawes is stained red for a short distance below the contact, but this is apparently due to the weathering of the ore. The upper contact is not so well-defined. There are stringers and thin layers of ore reaching upward into the Herkimer. This can be seen in all the outcrops, but it is particularly evident on College Hill creek.

Fauna. Many layers of the Kirkland are very fossiliferous, but the number of species represented are few. Crinoid stems are by far the most abundant fossils. Numerically bryozoans rank next. *Cladopora fiberosa, Eridotrypa solida, Acanthoclema asperum* and *Fenestella elegans* are the most abundant species. The brachiopod, *Schuchertella subplana,* is common. The formation is apparently devoid of ostracods.

Origin. After the deposition of the Irondequoit and the Willowvale the Upper Clinton sea contracted (see p. 99). During this period the land surface to the east seems to have been rejuvenated and a depression of the geosyncline followed. As a result the sea again moved eastward into Oneida county.

The origin of the Kirkland is apparently connected with the eastward migration of the sea. The area now covered by the Kirkland appears to have become partly shut off from the rest of the sea. In this basin of limited extent hematitic limestone formed with only a minor amount of sand or other clastic material. Following the Kirkland sedimentation, another oscillation of the strand line brought about conditions suitable to the deposition of the overlying arenaceous shales and thin-bedded sandstones.

Figure 17 Clinton, New York. Herkimer sandstone. Dawes Quarry.

The prerequisite for the formation of an iron ore in the Upper Clinton, as in the Lower, appears to have been the establishing of a certain area within the sea suitable to their deposition. The marine waters of the Clinton seem always to have carried sufficient iron in solution, but certain definite conditions were required for its precipitation. The evidence of iron in the Rochester sea is shown not only by the Kirkland but by the thin lean ores of the Lakeport core (section G, p. 183) and the North Victory outcrops (section 22, p. 156).

Herkimer Sandstone

Definition. Chadwick ('18, p. 351) named the Herkimer from exposures of that upper sandstone formation of the Clinton in southern Herkimer county.

Extent and lithologic characteristics. The Herkimer outcrops on two creeks in the vicinity of Clinton. The entire thickness can be observed on College Hill creek (section 32, p. 167), but because so much of the lower part is covered only the upper half may be studied in detail. The lower portion of the formation is well-exposed on Dawes Quarry creek (section 33, p. 169) and in Dawes Quarry itself (figure 17, p. 109).

The Herkimer is approximately 75 feet thick. The lower half of the formation consists of about equal parts of gray, calcareous, thin-bedded sandstones and dark gray, sandy and silty, calcareous shales. Some of the sandstones are fossiliferous and definitely marine. Other sandstones show wave and ripple marks often accompanied by mud cracks. Except for a great variety of fucoids which Hall ('43, p. 69–79) and Vanuxem ('42, p. 79–90) described as marine plant remains, but which may be inorganic in origin, these beach sandstones are devoid of any evidence of past life. The calcareous shales and particularly the shale partings between the marine sandstones yield most of the fossils.

The upper part of the Herkimer as exposed on College Hill creek is made up largely of sandstones with minor amounts of sandy shale. Some of the sandstones are calcareous. A layer two feet thick near the center of the formation contains sufficient calcite to make it a sandy limestone. Another such layer occurs at the base of this upper part. The shales are always sandy and except near the base are non-calcareous. The sandstones are mostly gray in color but there are three thick layers or masses which are red and brown. The red and some of the gray layers are cross-bedded and unfossiliferous. The fossils are confined almost entirely to the more calcareous layers.

East of Clinton the Herkimer was studied at Willowvale (section 34, p. 171), but there was apparently no change in lithology in that short distance. Hasty observation farther to the east shows that the cross-bedded gray and red layers are more plentiful in eastern Herkimer county and completely dominate the section in the south central part of that same county.

West of Clinton the Herkimer not only thickens but its character also changes rapidly. At Verona (section 31, p. 164) the formation is at least 80 feet thick and probably nearer 90 feet. Cross-bedded gray and red sandstones are entirely absent. The formation consists of gray to brownish gray, calcareous, argillaceous, thin-bedded sandstones with interbedded sandy, calcareous shales of the same color. Farther to the west in the Lakeport core (section G, p. 183) the stratigraphic interval is occupied by beds which more closely resemble the Rochester shale than the Herkimer sandstone.

Fauna. In comparison with the Rochester the Herkimer fauna is meager. The marine sandstones and the more calcareous shales, however, do furnish a fair assemblage of identifiable specimens. Brachiopods and pelecypods are the classes best represented. The more common brachiopods are *Dalmanella elegantula, Camarotoechia neglecta, Stropheodonta profunda, Schuchertella subplana, Leptaena rhomboidalis, Atrypa reticularis* and *Spirifer niagarensis*. The most abundant pelecypods are *Pterinea emaceratа, Modiolopsis subcarinatus* and *Leptodesma rhomboidea*. The cephalopod, *Dawsonoceras annulatum*, is a common fossil. The trilobites are represented by *Calymene niagarensis, Dalmanites limulurus* and *Homalonotus delphinocephalus*.

Ostracods are rare in the Herkimer and the few which are present are poorly preserved. They occur as natural casts in the shale between the more calcareous sandstones. The casts often are found to be made of fine sand and silt grains, and are easily broken. By collecting a large number of these poorly preserved specimens it was possible to identify the four species common to the *Paraechmina spinosa* zone. *Beyrichia veronica* was found in greater abundance than any other one species. In order of abundance the common forms are *Dizygopleura proutyi, P. postica* and *P. spinosa*. At Verona the ostracods are much more common than at Clinton and are much better preserved.

Origin. The Herkimer was deposited to the shoreward of the Rochester in the same sea. At times the actual shore line was located beyond the eastern boundary of Oneida county and marine shales and sandstones with their typical fossils were laid down in the Clinton-Willowvale area. At other times the strand line was in

Oneida county, and beach sandstones with their fucoids, mud cracks, wave and ripple marks were deposited. It would seem that at times the shore line was actually west of Clinton and that the red and brown and gray, cross-bedded sandstones formed under continental or at least semicontinental conditions.

The absence of any red sandstones and the presence of a few layers with mud cracks etc., tend to show that the area in the immediate vicinity of Verona was covered by the sea throughout the Herkimer. The great increase in the number of fossils also indicates that more nearly normal marine conditions prevailed. Before the close of Rochester deposition in the west or early in the sedimentation of the Lockport, marine conditions must have been absent from the vicinity of Clinton and to the east. This is shown by the presence of a marked unconformity at the top of the Herkimer and beneath the Lockport. How far the sea was forced westward and the agents of erosion were active is impossible to determine. The contact of the Herkimer and the Lockport is not exposed to the west of Clinton.

HISTORICAL GEOLOGY

LOWER CLINTON

The eastern half of the State at the beginning of Clinton time must have existed as a northward continuation of a large land mass of Appalachia, the main part of which lay to the south. This area which appears to have had considerable relief, was the source of most, if not all, the clastics of the Clinton. In contrast the western part of the State which had long been a part of the Appalachian geosyncline, was relatively near sea level with little relief.

A depression of the geosynclinal area in Clinton time brought marine waters into western New York. Ulrich and Bassler ('23, p. 267) recognized in Pennsylvania and elsewhere to the south a lower and older ostracod zone lying beneath the strata containing the *Zygobolba anticostiensis* assemblage, the *Z. excavata* zone of this report (p. 24). Since *Z. excavata* is the lowest and oldest ostracod zone represented in New York, it would appear that the sea migrated into the State from the south.

As the sea advanced it reworked the Grimsby and formed a thin but persistent mantle of Thorold sandstone throughout western New York (p. 29). The highly irregular argillaceous deposits of the Maplewood and the Neahga were probably also connected with this initial transgression (p. 37). The depression continued and the marine waters, becoming relatively clear, spread out far to the west moving the strand line beyond the boundaries of the State during the

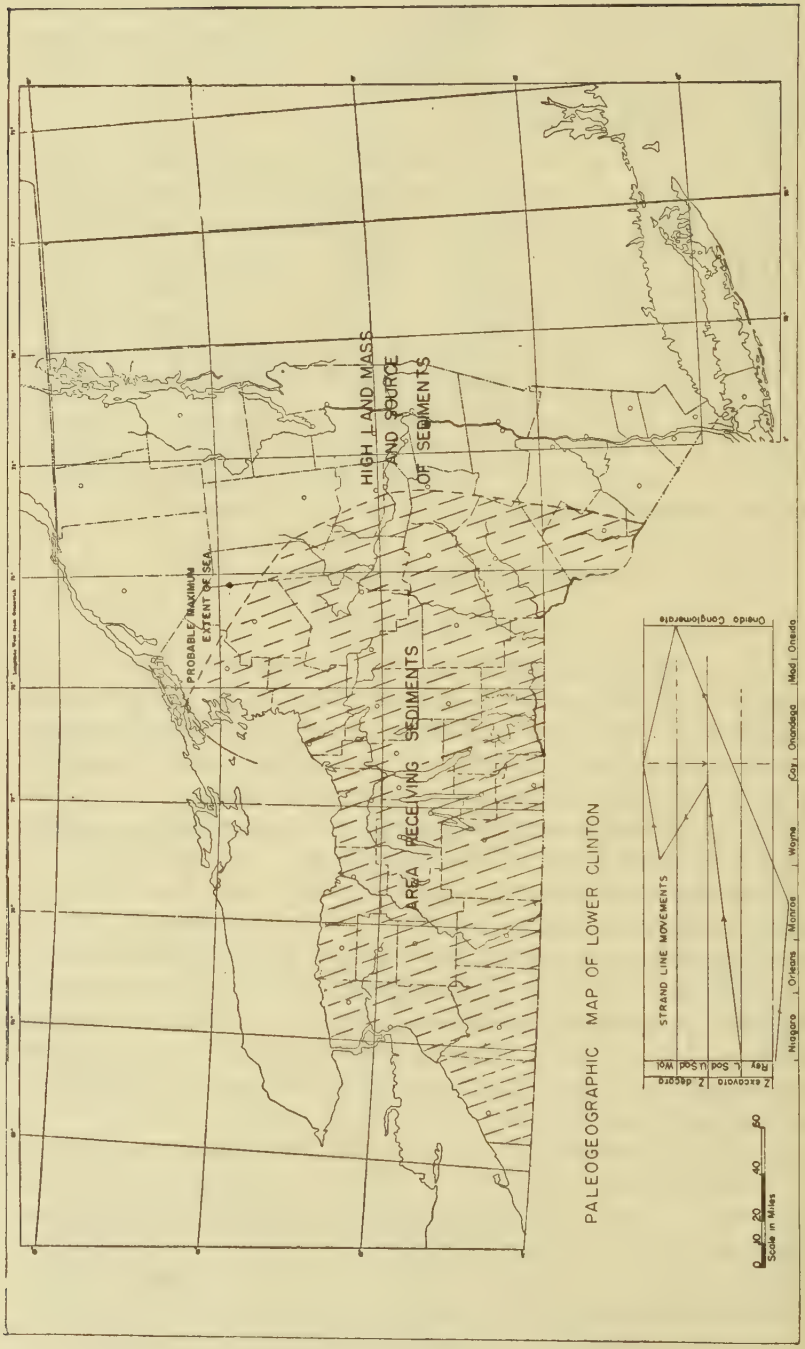

Figure 18 Paleogeographic map of Lower Clinton

deposition of the lowest Clinton limestone, the Reynales (figure 18, p. 114). To the east the sea had a more definite limit being bounded by a much higher land mass. Although the depression of the geosyncline permitted the seas to advance in that direction, the rate of migration was much slower. Furthermore, the clastic material derived from the adjacent land resulted in quite a different type of formation. In the immediate vicinity of the shore line the heavy sandy Oneida conglomerate formed. The lighter argillaceous material floated westward giving rise to the Bear Creek.

The strand line continued to move eastward through the deposition of the Lower Sodus (figure 18). The absence of any Lower Sodus west of Monroe county on the other hand indicates that the western strand line was forced eastward after the deposition of the widespread Reynales. This eastward migration of the western shore line may have been the result of a relative elevation of the western geosynclinal margin.

After the deposition of the Lower Sodus of Wayne county a relative elevation of the geosyncline may have caused a complete withdrawal of the sea from the State (p. 64). On the other hand the tilting which started in the Reynales may have continued in the Lower Sodus and forced the seas eastward into a relatively narrow trough in central New York (p. 65). The restriction of the area covered by the sea may explain the change from the limestones of the Reynales to the calcareous shales of the Lower Sodus.

During the Upper Sodus the sea again spread westward as well as eastward. This resulted in the deposition of the Upper Sodus unconformably on the lithologically similar Lower Sodus in Wayne county. Gradually the marine waters became free from sediment and the Upper Sodus gave way to the Wolcott. Soon after the beginning of Wolcott sedimentation both the eastern and western strand lines started to contract (figure 18, p. 114). At the close of the Wolcott the Lower Clinton sea was forced completely from New York into the deeper part of the geosynclinal area which seems to have lain to the south (p. 78).

MIDDLE CLINTON

The removal of the sea from western New York at the close of the Lower Clinton was probably accompanied by a general elevation which not only raised the geosyncline but also rejuvenated the land surface to the east and to the southeast. The identically similar lithology of the Oneida containing thin shales with ostracods characteristic of the Middle Clinton, and the same formation farther west with the Lower Clinton ostracods is substantial proof that the two divisions probably

derived their sediments from the same Appalachia. Furthermore the comparable size of the pebbles making up the coarser layers of both suggests that this land had a similar rugged relief.

Since there are no sediments of Middle Clinton age in western New York, that area probably existed as a land mass. The fact that the Lower Clinton is nowhere deeply eroded suggests that this land had a low elevation with only slight relief.

Marine conditions did not return even to central New York until well into the Middle Clinton (p. 78). The relatively narrow area, occupied by the Middle Clinton sediments along the line of outcrop, shows that the sea must have been confined to a narrow portion of northern central New York. The presence of a complete sequence of Lower and Middle Clinton formations in central Pennsylvania (F. M. Swartz, '34, p. 81–133 and Ulrich and Bassler, '23, p. 352–64), however, may indicate that the sea covered a much wider area in southern New York (figure 19, p. 117). It is possible that the deposits in northern central New York were formed in an indentation of the more general curving northern shore line whose exact position can only be a matter of conjecture.

The maximum development of the Middle Clinton is in eastern Oneida county. This suggests that that area may have been the first inundated. The sea spread westward as far as Cayuga county. This section is relatively thin and less clastic indicating that little or no sediment was derived from western New York. To the east the Middle Clinton overlaps the Lower Clinton deposits and rests directly upon the underlying Ordovician. This points to the conclusion that the land mass to the east and south was gradually being cut into and worn down. Marine conditions must have reached as far east as eastern Herkimer county.

After the deposition of the Sauquoit the sea was again forced southward into the deeper parts of the geosyncline. This may have been accomplished as a result of filling in the basin occupied by the marine waters. There is little or no evidence of any general elevation either in the uppermost Middle Clinton sediments themselves, or in the amount of erosion which they underwent before the advent of the Upper Clinton seas.

UPPER CLINTON

Erosion which had been acting upon the continuation of Appalachia in eastern New York since the beginning of the Silurian had succeeded by Upper Clinton time in wearing it down to one of only moderate relief. The absence of any coarse conglomerates in the Upper Clinton of central New York at least tends toward this conclusion.

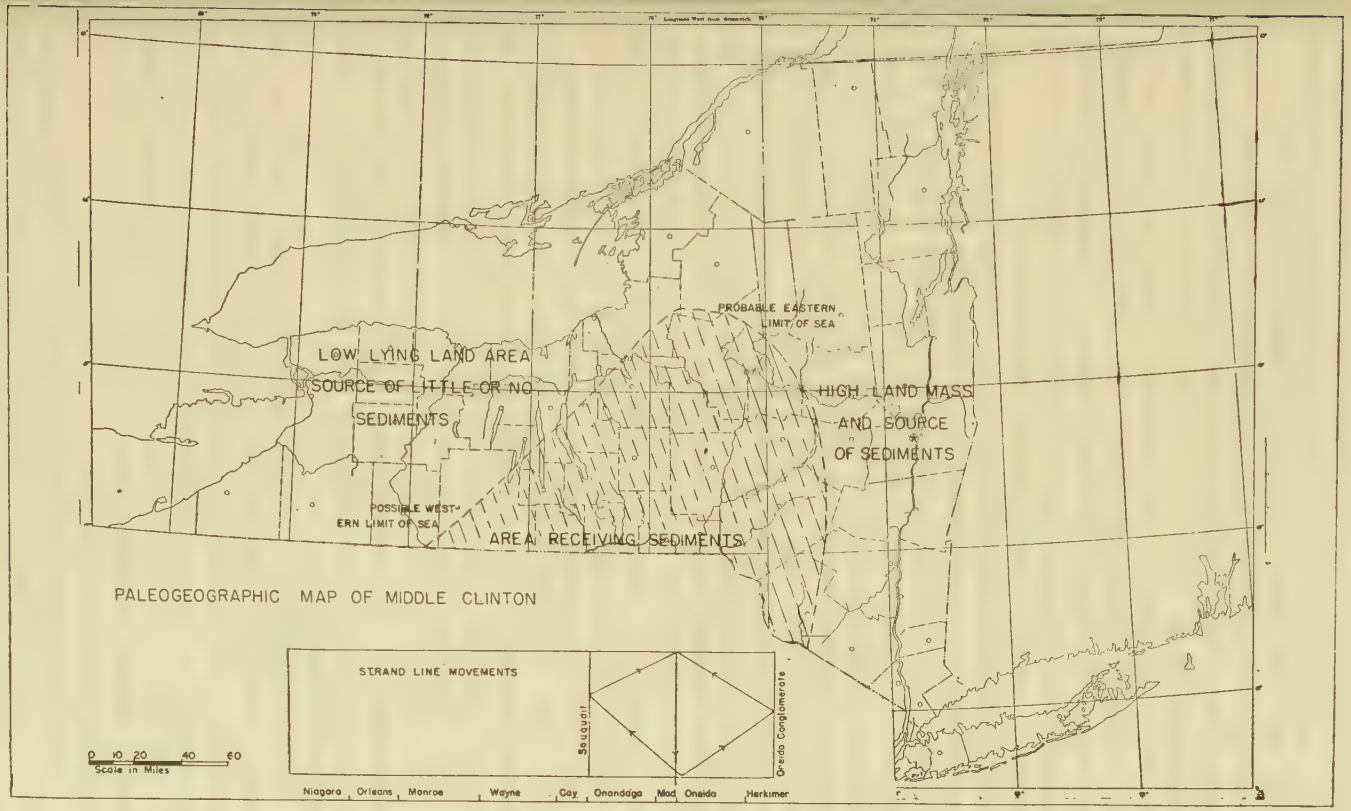
PROBABLE EASTERN LIMIT OF SEA
LOW LYING LAND AREA SOURCE OF LITTLE OR NO SEDIMENTS
HIGH LAND MASS AND SOURCE OF SEDIMENTS
POSSIBLE WESTERN LIMIT OF SEA
AREA RECEIVING SEDIMENTS
PALEOGEOGRAPHIC MAP OF MIDDLE CLINTON
STRAND LINE MOVEMENTS
Salina
Oneida Conglomerate
Niagara Orleans Monroe Wayne Cay Onondaga Mad Oneida Herkimer
0 10 20 40 60
Scale in Miles

Figure 19 Paleogeographic map of Middle Clinton

Farther to the south where lay the main part of Appalachia, conglomerates may have continued to form until the close of the Clinton (C. K. and F. M. Swartz, '30, p. 467–74 and '31, p. 621–62).

Western and central New York following the withdrawal of the Middle Clinton sea was subject to erosion. Evidences of this period are plentiful. Even so the total amount of rock carried and worn away does not appear to have been great. There are small but no great irregularities in the thickness of the Lower and Middle Clinton beds which can be directly attributed to erosion. This can be plausibly explained if it is assumed that the land was only slightly above sea level which condition would prevent rapid erosion.

Either a slight depression of the geosyncline or a slight rise in sea level brought marine conditions back to central New York. The path of invasion appears to have been through Madison county (p. 83). Into this Williamson sea of the Upper Clinton was carried much argillaceous material some of which may have formed as a residuum during the period of weathering which directly preceded. The geosyncline continued to sink, and the sea expanded westward and eastward, culminating in the relatively widespread submergence of Irondequoit time. At the height of the submergence the sea extended far beyond the western margins of the State, and true marine conditions existed as far east as Montgomery county. In the west clear limestones were formed. In the east argillaceous material contributed to the formation of shale and sandstones developed in the immediate vicinity of the shore. Even along the shore line no conglomerates formed.

Before the conclusion of Irondequoit sedimentation an elevation of the land mass and the neighboring part of the geosyncline forced the eastern strand line to recede as far as Oneida county (figure 20, p. 119). Erosion was quite active and the newly formed sediments were beveled (p. 99). What is more the rejuvenated land surface made available an abundance of coarser clastic material. The introduction of this material into the Upper Clinton sea brought to a close Irondequoit sedimentation.

At the beginning of Rochester time the western strand line was beyond the border of the state (figure 20). In central New York the strand line again migrated eastward. This eastward movement was accompanied by frequent oscillations, a fact attested to by the alternating marine and beach sediments (p. 112) in eastern Oneida county. Marine conditions appear to have extended as far east as southeastern Herkimer county.

Toward the close of the Rochester there was a definite retreat of the eastern strand line. This time it did not seem to have been accompanied by an elevation of the land mass. Possibly it was brought

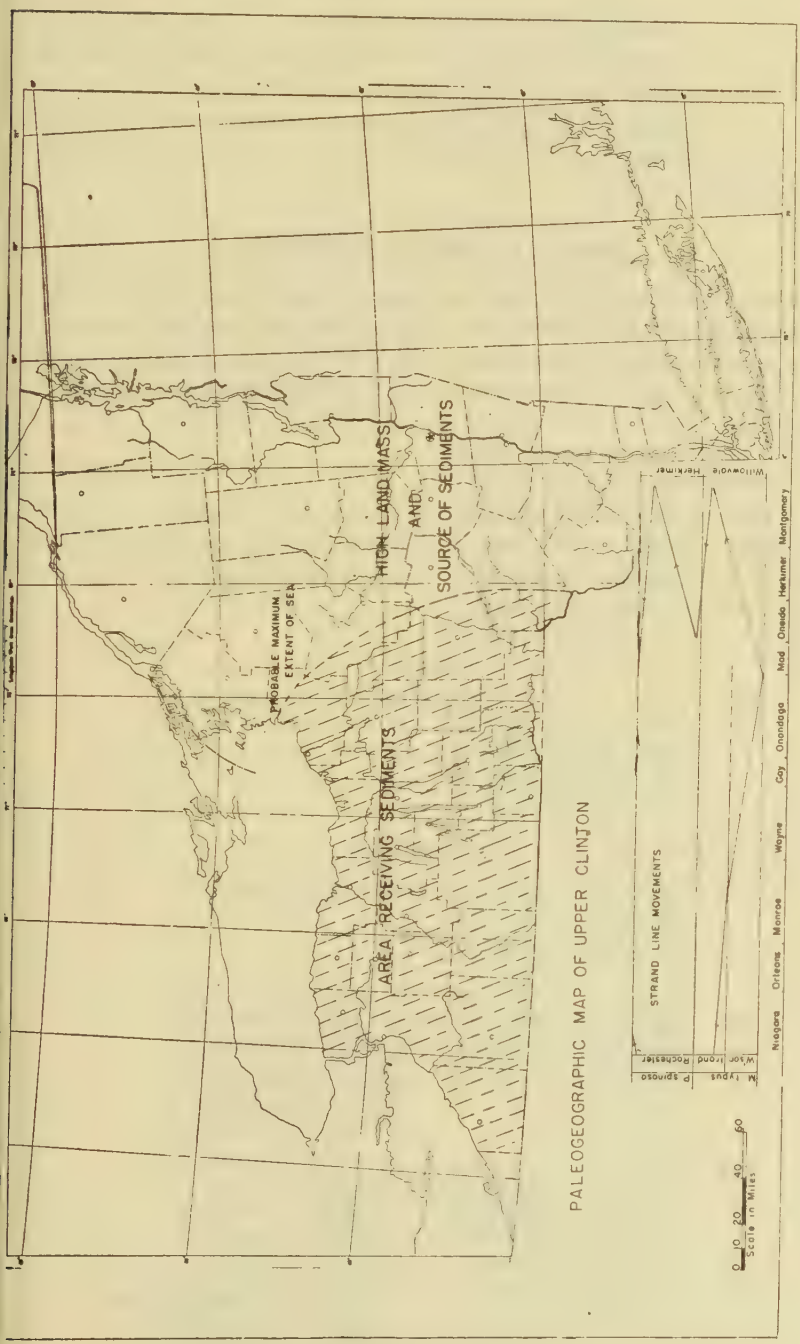
PALEOGEOGRAPHIC MAP OF UPPER CLINTON
AREA RECEIVING SEDIMENTS
HIGH LAND MASS AND SOURCE OF SEDIMENTS
PROBABLE MAXIMUM EXTENT OF SEA
STRAND LINE MOVEMENTS
Niagara Orleans Monroe Wayne Cay. Onondaga Mod. Oneida Herkimer Montgomery
Scale in Miles

Figure 20 Paleogeographic map of Upper Clinton

about by the filling in of the geosyncline by both continental and marine sediments. The Upper Clinton sea was not entirely forced from New York. The termination of the Rochester and the Clinton is considered to have been brought about by a widespread general submergence which produced conditions necessary for Lockport sedimentation.

DESCRIPTION OF SECTIONS

More than fifty outcrop sections have been measured between the Niagara gorge and Willowvale. Thirty-four of these are necessary in understanding the stratigraphy of the Clinton and are described in the following pages. Location of sections is shown on map (figure 1, page 7).

NIAGARA GORGE — SECTION 1

Towns of Lewiston and Niagara. County of Niagara. East side of Niagara gorge. Rochester is exposed in cliffs north of Niagara falls. Can be studied along the railroad which runs north from Lewiston along the base of the cliffs.

Top

Lockport

80 ft.	Dark gray to dark brownish gray dolomite. Upper parts thin-bedded with bituminous partings. Sparingly fossiliferous.	Eight species identified

Upper Clinton — Contact sharp

Rochester Shale

10 ft.	Brown to brownish gray, calcareous, dolomitic, massive shale. No resistant layers. Soft. Fossils rare.	No fossils collected
30 ft.	Bluish to brownish gray calcareous shale with thin limestone layers. Fossils rare.	*Leptaena rhomboidalis* *Strophonella striata* *Anastrophia interplicata* *Camarotoechia neglecta* *Pterinea emacerata* *Platyceras angulatum*
4 ft.	Bluish gray, very calcareous shale with numerous thin limestone layers. Limestone highly fossiliferous.	*Cladopora seriata* *Diploclema sparsum* *Ceramopora imbricata* *Fistulipora crustula* *Erdiotrypa striata* *Trematopora tuberculosa* *Chasmatopora asperatostriata* *Batostomella granulifera* *Fenestella elegans* *Semicoscinium tenuicebs*

		Lichenalia concentrica *Dalmanella elegantula* *Orthis flabellites* *Orthostrophia fasciata* *Rhipidomella hybridia* *Sowerbyella transversalis* *Camarotoechia neglecta* *Atrypa reticularis* *Trematospira camura* *Paraechmina spinosa* *Other ostracods*
20 ft.	Bluish gray, some brown-gray, calcareous shale with numerous limestone layers. Very fossiliferous with great diversity of fauna. Layers rich in fossils are interbedded with others practically barren.	*Enterolasma calculum* *Favosites hisingeri* *Dictyonema retiforme* *Ceramopora imbricata* *Chasmatopora asperatostriata* *Semicoscinium tenuiceps* *Lichenalia concentrica* *Pholidops squamiformis* *Dalmanella elegantula* *Orthis flabellites* *Rhipidomella hybrida* *Leptaena rhomboidalis* *Sowerbyella transversalis* *Strophonella patenta* *S. striata* *Schuchertella subplana* *Camarotoechia neglecta* *Rhynchotreta robusta* *Atrypa nodostriata* *A. reticularis* *Spirifer crispus* *S. niagarensis* *S. radiatus* *Whitfieldella cylindrica* *W. nitida* *W. nitida oblata* *Pterinea emacerata* *Diaphorostoma niagarense* *Platyceras angulatum* *Dawsonoceras annulatum* *Bumastus ioxus* *Dalmanites limulurus*
10 ft.	Bluish to brownish gray, calcareous shale with limestone layers. Contains famous crinoid beds, not so fossiliferous as overlying beds. Contact with underlying formation sharp.	*Caryocrinites ornatus* *Stephanocrinus angulatus* *Dalmanella elegantula* *Leptaena rhomboidalis* *Camarotoechia neglecta* *Conularia niagarensis*

Irondequoit Limestone

18 ft.	Light gray, some pink, crystalline limestone. Some layers composed of crinoid stems. Porous and brown to yellow when weathered. Fossil-	*Crinoid stems* *Leptaena rhomboidalis* *Stropheodonta profunda* *Rhynchotreta robusta* *Atrypa reticularis* *A. rugosa*

	iferous. Number of species limited. Toward the top very argillaceous reeflike limestone extends into base of overlying Rochester. Reef fossiliferous, but not examined closely.	*Whitfieldella cylindrica* *W. intermedia*
Lower Clinton		Unconformity
	Reynales Limestone	
4 ft.	Dark gray, fine grained, thin-bedded dolomitic limestone. Many of the layers are silty and argillaceous. Upper 12 inches dense and crystalline.	No fossils collected
5 ft.	Dark gray, dolomitic limestone, fine with coarse crystals imbedded in ground mass of fine material. Fossils rare.	*Buthotrephis gracilis* *Stropheodonta profunda* *Coelospira hemispherica*
3 ft.	Dark gray, very pyritic, phosphatic, finely crystalline, dolomitic limestone. Contact sharp with underlying formation.	*Stropheodonta corrugata* *S. profunda* *Coelospira hemispherica* *C. plicatula*
	Neahga Shale	
6 ft.	Smooth, slightly silty, slightly calcareous, thinly laminated, platy, green shale. Fossiliferous. Specimens poorly preserved.	*Buthotrephis gracilis* *Rhynchotreta cuneata americana* *Coelospira hemispherica* *C. plicatula* *Cuneamya alveata* *Pterinea emacerata* *Holopea obsoleta* *Tentaculites minutus* *Zygobolba curta* *Z. excavata*
1 ft.	Silty, sandy, green shale, thin-bedded, but not platy or smooth. Some layers calcareous. Some layers fine argillaceous sandstone. Fossils scarce and poorly preserved. Contact with underlying formation sharp.	*Coelospira hemispherica* *C. plicatula* *Holopea obsoleta*
	Thorold Sandstone	
6 ft.	Light gray, tightly cemented, argillaceous sandstone. Fine grained, argillaceous content not uniform. Cement silica, minor amount of carbonate. Unfossiliferous.	No fossils collected

Albion Group — Contact sharp

Grimsby Sandstone

50 ft. Red sandstone

LOCKPORT — SECTION 2

Town of Lockport. County of Niagara. West of the city of Lockport. Eighteen Mile creek. Stream has cut a deep gorge in the Clinton rock. Gorge called "The Gulf" on topographic map. Section measured is where road leading northwest from underpass at railroad crosses main branch of Eighteen Mile creek.

Top

Lockport

9 ft. Gasport member. Pure, crystalline crinoidal limestone. Highly fossiliferous. Contact with underlying rock very sharp.

7 ft. Dark gray, argillaceous, fine-grained, dolomitic limestones. Only slightly fossiliferous.

Upper Clinton — Contact slightly wavy

Rochester Shale

1 ft. 6 in. Transition zone. Dolomitic limestone interbedded with dark dolomitic calcareous shale. Fossils rare.

Dalmanella elegantula
Orthis flabellites
Sowerbyella transversalis
Atrypa reticularis
Dalmanites limulurus

25 ft. Brownish gray, calcareous and dolomitic shale with argillaceous limestone layers. Dolomitic content increased toward the top of formation. Compared with underlying slightly fossiliferous.

Enterolasma caliculum
Favosites pyriformis
Striatopora flexuosa
Dictyonema retiforme
Chasmatopora asperatostriata
Semicoscinium tenuiceps
Lichenalia concentrica
Pholidops squamiformis
Dalmanella elegantula
Rhipidomella hybrida
Leptaena rhomboidalis
Sowerbyella transversalis
Strophonella striata
Atrypa reticularis
Spirifer niagarensis
S. radiatus
Whitfieldella nitida oblata
Pterinea emacerata
P. undata
Diaphorostoma niagarense
Homalonotus delphinocephalus
Dalmanites limulurus

20 ft.	Bluish gray, some brownish gray, calcareous shale with numerous limestone layers. Very fossiliferous particularly near top where thin limestones are composed almost entirely of ostracods or bryozoans.	*Enterolasma caliculum* *Cladopora seriata* *Favosites hisingeri* *Striatopora flexuosa* *Diploclema sparsum* *Ceramopora imbricata* *Coeloclema cavernosum* *Spatiopora maculata* *Fistulipora crustula* *Mesotrypa nummiformis* *Eridotrypa solida* *E. striata* *Chasmatopora angulata* *C. asperatostriata* *Semicoscinium tenuiceps* *Rhinopora verrucosa* *Pholidops squamiformis* *Dalmanella elegantula* *Orthis flabellites* *Orthostrophia fasciata* *Rhipidomella hybrida* *Leptaena rhomboidalis* *Sowerbyella transversalis* *Anastrophia brevirostris* *A. interplicata* *Dictyonella corallifera* *Camarotoechia neglecta* *C. obtusiplicata* *Rhynchonella bidentata* *Atrypa nodostriata* *A. reticularis* *A. rugosa* *Spirifer crispus* *S. niagarensis* *S. radiatus* *S. sulcatus* *Trematospira camura* *Leiopteria subplana* *Pterinea emacerata* *P. undata* *Amphicoelia orbiculoides* *Platyceras angulatum* *P. niagarense* *Dawsonoceras annulatum* *Bumastus ioxus* *Homalonotus delphinocephalus* *Dalmanites limulurus* *Paracchmina postica* *P. spinosa* ***Dizygopleura proutyi*** *Beyrichia veronica and others*
20 ft.	Covered or poorly exposed. Apparently the same type of rock.	
10 ft.	Bluish to brownish gray, soft shale with some resistant argillaceous limestone layers. Fossils are comparatively rare but present. Contact sharp.	No fossils collected

Irondequoit Limestone

20 ft.	Light gray, coarsely crystalline, pyritic limestone. Some layers are composed of crinoid stems. Styolitic structures common. So-called reefs common in upper part and extends into the base of the overlying Rochester. Contact unconformable. Some poorly exposed.	In limestone Crinoid stems *Atrypa reticularis* *Spirifer niagarensis* *Whitfieldella cylindrica* *W. intermedia* In reefs *Dalmanella elegantula* *Leptaena rhomboidalis* *Sowerbyella transversalis* *Schuchertella subplana* *Strophonella patenta* *Anastrophia interplicata* *Camarotoechia neglecta* *Rhynchotreta cuneata americana* *Atrypa nodostriata* *A. reticularis* *A. rugosa* *Spirifer crispus* *S. niagarensis* *S. radiatus* *S. sulcatus* *Whitfieldella intermedia* *W. nitida* *W. nitida oblata* *Platyceras niagarensis* *Dawsonoceras annulatum* *Bumastus ioxus* *Calymene niagarensis* *Mastigobolbina trilobata* *M. typus* *Plethobolbina typicalis*

Reynales Limestone

10 ft.	Dark gray fine-grained dolomitic limestone. Lower 1 ft. 6 in. pyritic and phosphatic. Few thin fossiliferous layers above pyritic layers.	*Hyattidina congesta*

The lower part of the Reynales is best exposed along the side of the road which crosses the Gulf directly west of the city.

6 ft.	Dark gray fine-grained dolomitic limestone. Lower 2 ft. 6 in. pyritic and phosphatic. Thin light gray fossiliferous layer above the pyritic rock.	*Buthotrephis gracilis* *Stropheodonta corrugata* *Hyattidina congesta* *Coelospira hemispherica* *C. plicatula*

Thorold Sandstone

There are several fragmentary outcrops of Thorold in the area around Lockport. One of them shows the top to be not more than 8 to 10 inches below the lowest outcrop of the Reynales.

6 ft.	Light gray fine-grained argillaceous sandstone. Lightly cemented.	*Arthrophycus alleghaniensis*

Albion Group — Contact not observed

Grimsby Sandstone

Red sandstone

MIDDLEPORT — SECTION 3

Village of Middleport. Towns of Royalton and Hartland. County of Niagara. Outcrop located on a branch of Johnson creek. Rock is exposed in creek bed to north and south of Route 31.

Top

Lower Clinton

Reynales Limestone

4 ft.	Dark gray, fine-grained, dolomitic limestone. Fossils rare. Part poorly exposed.	*Hyattidina congesta*
8 ft.	Interstratified medium gray and dark gray, silty, dolomitic limestone. Some slightly cherty. Thin shale layers common. Fossiliferous.	*Buthotrephis gracilis* *Zaphrentis bilateralis* *Lichenalia concentrica* *Platystrophia biforata* *Rhipidomella circulus* *Stropheodonta corrugata* *S. profunda* *Rhynchotreta robusta* *Hyattidina congesta* *Coelospira hemispherica* *C. plicatula* *Holopea obsoleta* *Zygobolba curta* *Z. excavata*

GATES — SECTION 4

Barge Canal. Town of Gates. County of Monroe. The Barge canal is cut through the Rochester shale and the lower part of the Lockport from Lyell Avenue northward for about a mile. The following measured section is furnished by Dr H. L. Alling. Fossils personally collected and identified from the shale originally excavated from the canal. Therefore the exact horizon of the fossils is unknown.

Lockport

5 ft.	Dark gray even-bedded dolomite.
4 ft.	Dark gray, fairly evenly bedded dolomite.
12 ft.	Dark gray lenticular dolomite.
11 ft.	DeCew member. Argillaceous dolomite. "Curly" structure.

Upper Clinton — Contact unconformable (?)

Rochester Shale

Gates member of the Rochester

20 ft. Hard argillaceous limestone and calcareous shale.

Undifferentiated Rochester

20 ft. Thin - bedded, weak, brownish gray, thin-bedded shale.

Enterolasma caliculum
Diploclema sparsum
Coeloclema cavernosum
Spatiopora maculata
Chilotrypa ostiolata
Fistulipora crustula
F. tuberculosa
Mesotrypa nummiformis
Batostomella granulifera
Eridotrypa solida
E. striata
Lioclema asperum
Trematopora tuberculosa
Chasmatopora asperatostriata
Pseudohornea diffusa
Fenestella elegans
Polypora incepta
Semicoscinium tenuiceps
Nematopora raripora
Acanthoclema asperum
Clathropora frondosa
Pachydicta crassa
Diamesopora dichotoma
Stictotrypa punctipora
Dalmanella elegantula
Orthostrophia fasciata
Bilobites biloba
Leptaena rhomboidalis
Sowerbyella transversalis
Schuchertella subplana
Dictyonella corallifera
Camarotoechia neglecta
Rhynchonella bidentata
Atrypa reticularis
Spirifer radiatus
Homoeospira apriniformis
Pterinea emacerata
P. undata
Hormotoma subulata
Diaphorostoma hemisphericum
D. niagarense
Platyceras angulatum
P. niagarense
Orthoceras abruptum
Arctinurus nereus
Paraechmina spinosa

GENESEE GORGE — SECTION 5

City of Rochester. County of Monroe. Maplewood Park, *west side of gorge.* Rock is exposed in cliff north of park proper. Follow path north of park. Path is on terrace formed by Reynales limestone.

Top

Upper Clinton

Irondequoit Limestone

10 ft. 6 in.	Light gray crystalline limestone. Average layer 6 in. thick. Some crinoidal weathers porous and yellow. Few shale partings. Upper part contains reef-like bodies.	Crinoid stems *Leptaena rhomboidalis* *Sowerbyella transversalis* *Atrypa reticularis* *Spirifer radiatus* *Whitfieldella cylindrica* *Dawsonoceras annulatum* *Mastigobolbina typus* *Plethobolbina typicalis*
8 ft. 2 in.	Crystalline limestone interbedded with dark grayish green shale layers. Predominantly limestone in upper part with shale partings. Lower part predominantly shale. Limestone layers thin. Shale beds are more fossiliferous. Gradual transition to underlying shale.	*Dalmanella elegantula* *Orthis flabellites* *O. tenuidens* *Bilobites biloba* *Leptaena rhomboidalis* *Sowerbyella transversalis* *Schuchertella subplana* *Stropheodonta profunda* *Clorinda fornicata* *Atrypa reticularis* *Spirifer radiatus* *Whitfieldella cylindrica* *W. intermedia* *Dawsonoceras annulatum* *Calymene clintoni* *Mastigobolbina punctata* *M. trilobata* *M. typus* *Plethobolbina typicalis* *Beyrichia aff. lakemontensis* *Dibolbina n. sp.*

Williamson Shale

5 ft. 7 in.	Dark grayish green fissile shale. In the lower part are many thin black layers, literally filled with graptolites. A few thin limestone layers in upper part. In lower part some graptolite layers have a central waferlike mass of calcareous material.	*Chaetetes lycoperdon* *Retiolites geinitzianus venosus* *Monograptus clintonensis* *Bilobites biloba* *Leptaena rhomboidalis* *Sowerbyella transversalis* *Choneles cornutus* *Scenidium pyramidale* *Clorinda fornicata* *Atrypa reticularis* *Hormotoma sulcatum* *Mastigobolbina punctata* *M. trilobata* *M. typus* *Beyrichia aff. lakemontensis* *Dibolbina n. sp.*

0 to 2 in. Shell rubble. Marks the contact between Upper and Lower Clinton. Consists largely of broken Coelospira and Stropheodonta shells. Few Lower Clinton ostracods found. Irregular upper surface often covered with Monograptus. Few calcareous pebbles found.

Lower Clinton

Lower Sodus Shale

15 ft. 6 in.	Greenish gray shale with many thin layers of limestone interbedded. Dark gray or purple shale with green increases toward base of formation. Contact sharp. Limestone layers composed of Coelospira.	*Helopora fragilis* *Phaenopora ensiformis* *P. explanata* *Stropheodonta corrugata* *Coelospira hemispherica* *Ctenodonta machaeriformis* *Cyrtodonta alata* *Pterinea emacerata* *Holopea obsoleta* *Encrinurus ornatus* *Zygobolba curta* *Z. excavata* *Z. inflata* *Z. prolixa* *Z. rectangula*

Reynales Limestone

7 ft.	Light gray limestone layers 6 in. to 1 ft. in thickness. Few thin shale partings. No apparent gradation. First Pentamerus layer 3 in. below lowermost Sodus. Second Pentamerus layer 2 ft. 4 in. from top. Third Pentamerus layer 3 ft. 10 in. from top. Fourth Pentamerus layer 6 ft. 5 in. from top.	*Favosites favosideus* *Cannopora junciformis* *Helopora fragilis* *Fenestella tenuis* *Semicoscinium tenuiceps* *Phaenopora ensiformis* *P. explanata* *Platyostrophia biforata* *Stropheodonta corrugata* *S. profunda* *Pentamerus oblongus* *Coelospira hemispherica* *Rhynchotreta robusta* *Phacops trisulcatus* *Zygobolba curta* *Z. excavata*

Rest of Lower Clinton exposed but cliff too steep to work details.

Brewer Dock Member of Reynales Limestone

East side of gorge. Rock exposed along road leading down to old landing on bank of river. Rock also outcrops south of the road leading down to Brewer's dock. By working both the rock to the south of the road and along the road the whole section of the Pentamerus may be obtained. The upper part of the limestone is poorly exposed. Only that part of the section which was not available on the west side is described here.

Top

Lower Clinton

Reynales Limestone

6 ft. 4 in.	Light gray crystalline limestone. This lower part is thinner bedded than the upper part. Many shale partings. Fifth Pentamerus layer occurs 8 ft. 9 in. from the top or 4 ft. 7 in. above iron ore. Sixth Pentamerus layer is only 4 in. above the ore. Contact sharp.	*Zaphrentis bilateralis* *Favosites favosideus* *Cannopora junciformis* *Chasmatopora angulatum* *Fenestella tenuis* *Helopora fragilis* *Phaenopora ensiformis* *Platystrophia lynx* *Stropheodonta corrugata* *Strophonella patenta* *Pentamerus oblongus* *Coelospira hemispherica* *Goldius niagarensis* *Zygobolba curta* *Z. excavata* *Z. prolixa*

Furnaceville Iron Ore

8 in. to 14 in.	Hematitic limestone commonly called "Iron Ore". Fossils replaced by hematite. Contact sharp.	Crinoid stems *Helopora fragilis* *Phaenopora ensiformis* Many other bryozoons *Stropheodonta corrugata* *Coelospira hemispherica* *Zygobolba excavata* *Z. prolixa*

Brewer Dock Member of Reynales Limestone

3 ft.	Light gray crystalline limestone with medium gray argillaceous, fine-grained, pyritic limestone. Thin-bedded. Some shale. Contact sharp.	*Phaenopora ensiformis* *P. explanata* *Stropheodonta corrugata* *Hyattidina congesta* *Coelospira hemispherica* *Bucania bellapuncta* *B. stigmosa* *Hormotoma subulata* *Cyclora subulata*

Maplewood Shale

20 ft. 6 in.	Smooth, platy, green shale. Near base becomes sandy and glauconitic. Contact not well-defined. Fossils rare.	No fossils collected

Thorold Sandstone

5 ft.	Gray sandstone. Very hard and well-cemented. Fine-grained silt size material abundant.	*Arthrophycus alleghaniensis*

Albion Group

Contact sharp

Grimsby

Red sandstone

DENSMORE CREEK SECTION 6

Town of Irondequoit. County of Monroe. Densmore creek crossed by Norton street. Rock outcrops at bridge and to the south of bridge. North of bridge is a small fault.

Top

Upper Clinton

Rochester Shale

13 ft.10 in.	Dark bluish gray shale. Some very calcareous layers. Fossils very abundant.	*Enterolasma caliculum* *Dictyonema subretiforme* *Diploclema sparsum* *Ceramopora imbricata* *Coeloclema cavernosum* *Chilotrypa ostiolata* *Fistulipora crustula* *Mesotrypa nummiformis* *Chasmatopora asperatostriata* *Fenestella elegans* *Acanthoclema asperum* *Clathropora frondosa* *Diamesopora dichotoma* *Other bryozoans* *Dalmanella elegantula* *Orthis flabellites* *O. punctostriata* *Bilobites biloba* *Leptaena rhomboidalis* *Schuchertella subplana* *Stropheodonta profunda* *Strophonella striata* *Camarotoechia neglecta* *Rhynchonella bidentata* *Atrypa nodostriata* *A. reticularis* *A. rugosa* *Spirifer niagarensis* *S. radiatus* *S. sulcata* *Whitfieldella intermedia* *W. nitida* *Leptodesma rhomboideum* *Pterinea emacerata* *Amphicoelia orbiculoides* *Platyceras angulatum* *P. niagarense* *Dawsonoceras annulatum* *Tentaculites minutus* *Conularia niagarensis* *Bumastus ioxus* *Arctinurus nereus* *Homalonotus delphinocephalus* *Dalmanites limulurus* *Paraechmina postica* *P. spinosa* *Dizygopleura proutyi* *Beyrichia veronica*

Between Norton Street bridge and Densmore Road bridge there are no outcrops. Rock outcrops under the bridge and continues for some distance downstream.

Top

Lower **Clinton**

Reynales Limestone

4 ft.	Light gray crystalline limestone. Few shale partings.	*Zaphrentis bilateralis* *Favosites favosideus* *Chaetetes lycoperdon* *Chasmatopora angulatum* *Fenestella tenuis* *Semicoscinium tenuiceps* *Platystrophia lynx* *Rhipidomella circulus* *Stropheodonta corrugata* *Strophonella patenta* *Pentamerus oblongus* *Rhynchonella bidens* *Rhynchotreta robusta* *Coelospira hemispherica* *Zygobolba excavata*

Furnaceville Iron Ore

9 in.	Hematitic limestone, Hematite replaces the limestone. Pieces of partly replaced limestone common. Some as islands of unreplaced limestone in "Ore". Fossils dwarf and broken.	Crinoid stems *Chasmatopora angulata* *Stropheodonta corrugata* *Strophonella patenta* *Coelospira hemispherica* *Cyclora subulata* *Zygobolba curta*

Brewer Dock Member of Reynales Limestone

2 ft. 9 in.	Light gray crystalline limestone with a few shale partings. This limestone is found just under the cap rock of the little falls.	*Stropheodonta corrugata* *Rhynchotreta robusta* *Hyattidina congesta* *Coelospira hemispherica* *Bucania stigmosa* *Cyclora subulata* *Holopea obsoleta*

Maplewood Shale

14 ft. 8 in.	Smooth, green, platy shale. Black phosphatic nodules common in lower part. Fossils rare and poorly preserved. Fossils most plentiful in layer out cropping on stream bank 110 ft. below falls. Fossils found associated with phosphatic nodules. Basal part covered.	*Buthotrephis gracilis* *Lingula perovata* *Rhipidomella circulus* *Coelospira hemispherica?* *Coelospira plicatula* *Pterinea (emacerata?)* *Holopea obsoleta*
8 ft.	Missing or too poorly exposed for study.	

Albion Group — Contact sharp

Grimsby Sandstone

Red sandstone

GLEN EDYTHE — SECTION 7

Town of Webster. County of Monroe. East side of Irondequoit bay. Small creek flowing into Irondequoit bay. Some rock is exposed along the road leading to Glen Edythe. Best outcrop in stream bed.

Top

Lower Clinton

Reynales Limestone

4 ft. 6 in.	Light gray crystalline limestone. Thin-bedded. Few shale partings.	*Buthotrephis gracilis* *Zaphrentis bilateralis* *Chaetetes lycoperdon* *Helopora fragilis* *Phaenopora ensiformis* *Rhipidomella circulus* *Stropheodonta corrugata* *Strophonella patenta* *Pentamerus oblongus* *Rhynchonella emacerata* *Rhynchotreta robusta* *Coelospira hemispherica* *Encrinurus ornatus* *Zygobolba prolixa*
1 ft.	Limestone. Light gray, crystalline, very fossiliferous. Probable Furnaceville horizon of Genesee gorge.	*Stropheodonta corrugata*
3 ft.	Light gray, crystalline, pyritic limestone. Some dark gray, argillaceous limestone. Shale partings common. Contact sharp.	*Phaenopora ensiformis* *P. explanata* *Helopora fragilis* *Nematopora raripora* *Hyattidina congesta* *Coelospira hemispherica* *Hormotoma subulata* *Cyclora subulata*
15 ft. 2 in.	Smooth, green, platy, slightly calcareous shale. Sandy with phosphatic nodules near base. Contact clearly defined.	No fossils collected

Thorold Sandstone

3 ft. 4 in.	White sandstone. Imbedded in the sandstone layers are small pebbles of shale.	*Arthrophycus alleghaniensis*

Albion Group — Contact clearly defined

Grimsby Sandstone

50 ft. Red sandstone

FRUITLAND ORE PIT SECTION 8

Town of Ontario. County of Wayne. One mile north of Fruitland on the Fruitland-Lakeside road. Exposure 1150 ft east of road in the open cut ore pits. The only iron ore mine operating in Wayne county at the present time.

Top

Lower Clinton

Reynales Limestone

1 ft. 11 in.	Light gray, crystalline, slightly cherty limestone. Fossils and especially the Pentamerus are slightly silicified.	*Zaphrentis bilateralis* *Fenestella tenuis* *Chasmatopora angulata* *Stropheodonta corrugata* *Pentamerus oblongus* *Coelospira hemispherica*
4 ft. 4 in.	Light gray limestone, Argillaceous limestone common. Some thin sandy layers. Ostracods are very common. Some are well-preserved.	*Zaphrentis bilateralis* *Favosites favosideus* *Fistulopora tuberculosa* *Chasmatopora angulata* *Fenestella tenuis* *Semicoscinium tenuiceps* *Helopora fragilis* *Phaenopora ensiformis* *P. explanata* *Dalmanella elegantula* *Platystrophia biforata* *Rhipidomella circulus* *Stropheodonta corrugata* *S. profunda* *Rhynchotreta robusta* *Coelospira hemispherica* *Tentaculites minutus* *Goldius niagarensis* *Encrinurus ornatus* *Homalonotus n. sp.* *Phacops trisulcata* *Zygobolba curta* *Z. excavata* *Z. inflata* *Z. prolixa* *Z. rectangula*

Furnaceville Iron Ore

1 ft. 6 in.	Hematitic limestone. Dominantly a fossil ore but oolitic form common. Contact sharp.	*Zaphrentis bilateralis* Crinoid stems *Helopora fragilis* *Phaenopora constellata* *P. ensiformis* *P. explanata* *Stropheodonta corrugata* *Strophonella patenta* *Coelospira hemispherica* *Hormotoma subulata* *Cyclora subulata* *Encrinurus ornatus* *Zygobolba curta* *Z. excavata* *Z. prolixa* *Z. rectangula*

Thorold Sandstone

6 in.	Gray sandstone with shale pellets imbedded in the sandstone. The top layer contained phosphatic nodules. The whole thickness is not present. Ore is frozen to top of gray sandstone. Thickness exposed on creek near-by.	No fossils collected

FISH CREEK — SECTION 9

Town of Ontario. County of Wayne. Outcrop is a short distance north of United States Highway 104 in stream bed near old mill.

Top

Lower Clinton

Wolcott Limestone

6 ft. 2 in.	Light gray, crystalline limestone. Toward the base the limestone becomes thin-bedded. Shale and limestone interbedbed. Contact transitional.	*Favosites favosideus* *F. pyriformis* *Chaetetes lycoperdon* *Chasmatopora angulata* *Fenestella tenuis* *Semicoscinium tenuiceps* *Rhinopora verrucosa* *Platystrophia biforata* *Leptaena rhomboidalis* *Pentamerus oblongus* *Rhynchotreta robusta* *Strophostylus cancellatus* *Zygobolba decora* *Mastigobolbina incipiens* *M. retifera*

Upper Sodus Shale

3 ft. 2 in.	Green shale with limestone layers. Apparent transition between limestone and shale.	*Helopora fragilis* *Phaenopora ensiformis* *Nematopora raripora* *Stropheodonta corrugata* *Rhynchotreta robusta* *Coelospira hemispherica* *Zygobolba decora* *Z. robusta* *Mastigobolbina incipiens* *M. retifera*

SALMON CREEK WEST — SECTION 10

Town of Williamson. County of Wayne. The outcrops start 175 feet north of United States Highway 104 and continue intermittently to the railroad bridge (Rome, Watertown and Ogdensburg Division of the New York Central). The outcrops are deeply weathered. This is the type locality of the Williamson shale.

Top

Upper Clinton

Rochester Shale

9 ft. 6 in.	Brownish gray shale with limy layers. Very fossiliferous contact not observed, but fragments of this shale in bank just above following limestone.	*Enterolasma caliculum* *Zaphrentis turbinata* *Mesotrypa nummiformis* *Fenestella elegans* *Diamesopora dichotoma* *Dalmanella elegantula* *Leptaena rhomboidalis* ***Orthis flabellites*** *Schuchertella subplana* *Stropheodonta profunda* *Camerotoechia obtusiplicata* *C. neglecta* *Atrypa reticularis* *Spirifer radiatus* *Whitfieldella nitida* *W. nitida oblata* *Pterinea emaccrata* *Amphicoelia orbiculoides* *Platyceras niagarense* *Dawsonoceras annulatum* *Bumastus ioxus* *Arctinurus nereus* *Homalonotus delphinocephalus* *Dalmanites limulurus* *Paraechmina postica* *P. spinosa* *Dizygopleura proutyi* *Bcyrichia veronica*

Irondequoit Limestone

7 ft. 10 in.	Crystalline limestone. Shale partings are common. Outcrop in bank near site of old saw mill, 1175 ft. north of Route 104. Contact gradational.	*Leptaena rhomboidalis* *Atrypa nodostriata* *A. reticularis* *Whitfieldella cylindrica* *W. intermedia* *Mastigobolbina typus* *Plethobolbina typicalis*
8 ft. 4 in.	Crumbly dark bluish gray calcareous shale with some argillaceous limestone layers. Contact gradational.	*Dalmanella elegantula* *Bilobites biloba* *Leptaena rhomboidalis* *Sowerbyella transversalis* *Clorinda fornicata* *Atrypa nodostriata* *A. reticularis* *Spirifer radiatus* *S. sulcata* *Whitfieldella cylindrica* *W. intermedia* *Pterinea emacerata* *Dawsonoceras annulatum* *Calymene clintoni* *Dalmanites limulurus* *Mastigobolbina punctata* *M. trilobata* *M. typus* *Plethobolbina typicalis* *Dibolbina n. sp.*

Williamson Shale

6 ft. 10 in.	Dark greenish gray fissile shale. Thin black layer near base.	*Enterolasma caliculum* *Dictyonema gracile* *D. retiforme* *Retiolites geinitzianus venosus* *Monograptus clintonensis* *Pholidops squamiformis* *Dalmanella elegantula* *Leptaena rhomboidalis* *Sowerbyella transversalis* *Schuchertella subplana* *Chonetes cornutus* *Scenidium pyramidale* *Rhynchonella bidens* *Atrypa reticularis* *Cyrtia meta* *Spirifer radiatus* *Ctenodonta machaeriformis* *Orthoceras bassleri (?)* *Calymene clintoni* *Beyrichia aff. lakemontensis* *Mastigobolbina punctata* *M. trilobata* *M. typus* *Dibolbina n. sp.*

Lower Clinton — Contact sharp

Wolcott Limestone

7 ft. 2 in.	Light bluish gray crystalline limestone with shale partings.	*Zaphrentis bilateralis* *Favosites favosideus* *Chaetetes lycoperdon* *Chasmatopora angulata* *Fenestella tenuis* *Platystrophia biforatus* *Pentamerus oblongus* *Leptaena rhomboidalis* *Rhynchotreta robusta* *Atrypa reticularis* *Coelospira hemispherica* *Zygobolba decora*

MINK CREEK — SECTION 11

Town of Williamson. County of Wayne. Outcrop is both north and south of United States Highway 104. From the highway the outcrop extends about 550 ft. to the north and about 900 ft. to the south.

Top

Upper Clinton

Rochester Shale

25 ft.	Brownish gray calcareous shale with some argillaceous limestone layers. Fossils are not abundant.	*Enterolasma caliculum* *Zaphrentis turbinata* *Fistulipora tuberculosa* *Mesotrypa nummiformis* *Chasmatopora asperatostriata* *Fenestella elegans* *Dalmanella elegantula* *Orthis flabellites*

Leptaena rhomboidalis
Sowerbyella transversalis
Schuchertella subplana
Stropheodonta profunda
Camarotoechia neglecta
C. obtusiplicata
Atrypa reticularis
Spirifer niagarensis
S. radiatus
Whitfieldella nitida oblata
Pterinea emacerata
Dawsonoceras annulatum
Arctinurus nereus
Homalonotus delphinocephalus
Dalmanites limulurus
Paraechmina spinosa

Mink creek flows over glacial till for about one and a quarter miles. The next outcrop is located where Mink creek crosses second east-west road south of Lake Ontario. Rock occurs in the stream bed and along the banks on both sides of the road.

Lower Clinton

Reynales Limestone

5 ft. 6 in.	Dark to medium gray limestone. The highest layer contains some chert. There are a number of shale layers. Fossils silicified. Contact sharp. The highest layer outcrops 1150 ft. south of road. The lowest layer is 575 ft. south of road.	*Zaphrentis bilateralis* *Cannapora junciformis* *Stromatopora constellata* *Dimerocrinus brachiatus* *Rhinopora verrucosa* *Leptaena rhomboidalis* *Stropheodonta corrugata* *Pentamerus oblongus* *Rhynchotreta robusta* *Spirifer radiatus ?* *Coelospira hemispherica* *Strophostylus cancellatus* *Discosorus conoideus* *Zygobolba curta* *Z. excavata* *Z. prolixa* *Z. rectangula*

Furnaceville Iron Ore

9 in.	Hematitic limestone. Fossiliferous type. Fossils fragmentary. Some dwarf forms.	Crinoid stems *Helopora fragilis* *Phaenopora constellata* *P. ensiformis* *P. explanata* *Coelospira hemispherica* *Tentaculites minutus*

Thorold Sandstone

2 ft. 6 in.	Covered.	
1 ft. 6 in.	Gray sandstone with embedded green shale pellets. Outcrops just under bridge.	*Arthrophycus alleghaniensis*
2 ft. 5in.	Covered.	

Albion Group

Grimsby Sandstone

Red sandstone. First outcrop of this formation is 85 ft. north of bridge.

Weed Creek — Section 12

Town of Sodus. County of Wayne. Outcrop is located south of the Lake road on creek which is locally known as Weed's creek. It is the first stream flowing into Lake Ontario east of Nigger Hill, shown on the topographic map. Outcrop is on the eastern branch of that creek.

Top

Lower Clinton

Reynales Limestone

5 ft. 2 in.	Dark gray to medium gray, cherty, sandy limestone. Very sandy with stringers of hematite near the base. Important because of abundance of chert and absence of bryozoans. Contact sharp and is located 300 ft. south of road.	*Zaphrentis bilateralis* *Favosites favosideus* *Cannapora junciformis* *Leptaena rhomboidalis* *Stropheodonta corrugata* *Pentamerus oblongus* *Rhynchotreta robusta* *Coelospira hemispherica* *Holopea obsoleta* *Goldius niagarensis* *Encrinurus ornatus* *Zygobolba curta* *Z. excavata* *Z. prolixa*

Furnaceville Iron Ore

8 in.	Hematitic limestone. Iron content very low. Phosphatic pebbles common. Fossils fragmentary and dwarf. Contact sharp.	*Helopora fragilis* *Phaenopora ensiformis* *Coelospira hemispherica* *C. plicatula*

Thorold Sandstone

4 ft. 3 in.	Gray sandstone with embedded clay pellets. The upper 4 in. is an olive-green sandy shale with phosphatic pebbles.	*Arthrophycus alleghaniensis*

Albion Group

Grimsby Sandstone

2 ft. Red sandstone. Outcrop continues to road. More Grimsby is exposed north of Lake road.

SALMON CREEK EAST SECTION 13

Town of Sodus. County of Wayne. Outcrop near the hamlet of Wallington where the east branch of Salmon creek is crossed by United States Highway 104. The outcrop extends to the south 225 ft. and to the north 975 ft. of the highway. See also page 175.

Top

Upper Clinton

Rochester Shale

21 ft. 6 in.	Brownish gray shale containing some argillaceous limestone and some thin crystalline fossiliferous limestone layers. Fossils are abundant and well-preserved.	*Enterolasma caliculum* *Favosites constrictus* *F. pyriformis* *Dictyonema retiforme* *Ceramopora imbricata* *Mesotrypa nummiformis* *Chasmatopora asperatostriata* *Fenestella elegans* *Dalmanella elegantula* *Orthis flabellites* *Rhipidomella hybrida* *Sowerbyella transversalis* *Schuchertella subplana* *S. tenuis* *Stropheodonta profunda* *Camarotoechia neglecta* *Atrypa reticularis* *A. rugosa* *Spirifer crispatus?* *S. radiatus* *S. sulcata* *Whitfieldella naviformis* *W. nitida* *W. nitida oblata* *Pterinea emacerata* *Platyceras niagarense* *Cyrtoceras subcancellatum* *Dawsonoceras annulatum* *Bumastus ioxus* *Arctinurus nereus* *Homalonotus delphinocephalus* *Dalmanites limulurus* *Paracchmina postica* *P. spinosa* *Beyrichia veronica*

Salmon creek flows over till for about a mile and a half. Rock again appears in the stream bed 650 feet south of where the second east-west road south of Lake Ontario crosses the east branch of Salmon creek.

Lower Clinton

Upper Sodus Shale

10 ft.	Green, calcareous shale with limestone layers which are composed of Coelospira (pearly layers). Upper part is	*Helopora fragilis* *Phaenopora ensiformis* *Stropheodonta corrugata* *Coelospira hemispherica* *Tentaculites minutus*

	poorly exposed. Lower part is well-exposed. Contact, marked by an erosional unconformity, is 385 ft. north of bridge.	*Calymene senaria* *Calymenella rostrata* *Phacops trisulcata* *Zygobolba decora* *Z. intermedia* *Z. robusta*

Lower Sodus Shale

14 ft.	Green to greenish gray, calcareous shale with pearly layers, also dark gray or purple shale. Limestone more abundant in the upper part. Dark gray layers increase in abundance to the base.	*Phaenopora ensiformis* *Chaetetes lycoperdon* *Helopora fragilis* *Lingula perovata* *Rhynchonella emacerata* *Stropheodonta corrugata* *Coelospira hemispherica* *Pterinea emacerata* *Orthodesma curtum* *Tentaculites minutus* *Zygobolba curta* *Z. excavata* *Z. inflata* *Z. prolixa* *Z. rectangula*
5 ft. 6 in.	Dark gray or purple shale. Thin limestones very rare. The whole section of Lower Sodus exposed either in the stream bed or in the banks along the stream. Contact sharp, located 3800 ft. below bridge.	*Helopora fragilis* *Phaenopora ensiformis* *Lingula perovata* *Stropheodonta corrugata* *Coelospira hemispherica* *Pterinea emacerata* *Orthodesma curtum* *Ctenodonta lata* *C. machaeriformis* *C. mactriformis* *Holopea obsoleta* *Tentaculites minutus* *Zygobolba curta* *Z. excavata* *Z. inflata* *Z. prolixa* *Z. rectangula*

Reynales Limestone

15 ft.	Dark gray argillaceous limestone with medium gray crystalline layers in lower 8 ft. Upper 3 ft. thin-bedded with shale partings. Upper 7 ft. very cherty. Lower 3 ft. impregnated with hematitic layers. Pentamerus layers confined to basal part. Lowest layers covered by mill pond except in a dry season. Contact sharp, located 5100 ft. below bridge.	*Buthotrephis gracilis* *Zaphrentis bilateralis* *Favosites favosideus* *Cannapora junciformis* *Stropheodonta corrugata* *Pentamerus oblongus* *Rhynchotreta robusta* *Coelospira hemispherica* *Ctenodonta lata* *C. machaeriformis* *Pterinea emacerata* *Zygobolba curta* *Z. excavata* *Z. inflata*

Furnaceville Iron Ore

1 ft.	Upper 6 in. hematitic limestone. Lower 6 in. green shale with some oolites of hematite. Phosphatic nodules present. Contact sharp.	*Helopora fragilis* *Phaenopora ensiformis* *P. explanata* *Rhipidomella circulus* *Stropheodonta corrugata* *Coelospira hemispherica* *Holopea obsoleta* *Zygobolba curta* *Z. prolixa*

Thorold Sandstone

3 ft. 9 in.	Gray sandstone. Slightly calcareous with embedded clay pellets. Prominent closely spaced joints cause the sandstone to break in rectangular pieces.	*Arthrophycus alleghaniensis*

Albion Group

Grimsby Sandstone

20 ft. Red sandstone

SECOND CREEK SECTION 14

Town of Sodus. County of Wayne. Hamlet of Alton. Rock outcrops for 250 ft. south of the bridge on United States Highway 104 and to the north as far as the Alton-Sodus Point road.

Top

Upper Clinton

Rochester Shale

9 ft. 3 in.	Brownish gray calcareous shale. A few limestone layers. Fossils not abundant and rock badly weathered.	*Mesotrypa nummiformis* *Dalmanella elegantula* *Rhipidomella hybrida* *Leptaena rhomboidalis* *Sowerbyella transversalis* *Schuchertella subplana* *S. tenuis* *Stropheodonta profunda* *Atrypa reticularis* *Spirifer niagarensis* *Whitfieldella naviformis* *W. nitida oblata* *Pterinea emacerata* *Bumastus ioxus* *Arctinurus nereus* *Homalonotus delphinocephalus* *Dalmanites limulurus* *Beyrichia veronica*

Second creek flows over till for about one mile, below which the section continues and extends north of the old mill on the east-west road leading through the Alasa farms (former Shaker tract).

Upper Clinton

Rochester Shale

15 ft. 6 in.	Brownish gray shale. A few layers are calcareous. Near the base are a few argillaceous limestones. First ostracods appear 10 ft. 4 in. above base. Contact sharp and located 2525 ft. south of first east-west road to cross Second creek north of Alton.	*Enterolasma caliculum* *Zaphrentis turbinata* *Favosites pyriformis* *Dimerocrinus liliiformis* *Lyriocrinus dactylus* *Eucalyptocrinus caelatus* *Lecanocrinus macropetalus* *Stephanocrinus angulatus* *S. gemmiformis* *Chasmatopora asperatostriata* *Fenestella elegans* *Rhinopora verrucosa* *Pholidops squamiformis* *Orthis flabellites* *Dalmanella elegantula* *Sowerbyella transversalis* *Rhipidomella hybrida* *Schuchertella interstriata* *S. subplana* *S. tenuis* *Stropheodonta profunda* *Leptaena rhomboidalis* *Camarotoechia neglecta* *C. obtusiplicata* *Atrypa reticularis* *Atrypina disparilis* *Spirifer niagarensis* *S. radiatus* *S. sulcatus* *Leiopteria subplana* *Pterinea emacerata* *P. undata* *Platyceras angulatum* *P. niagarense* *Dawsonoceras annulatum* *Homalonotus delphinocephalus* *Cheirurus niagarensis* *Dalmanites limulurus* *Paraechmina spinosa* *Beyrichia veronica* *Dizygopleura proutyi*

Irondequoit Limestone

7 ft. 10 in.	Light gray, crystalline pyritic limestone. The upper part is more massive than the lower part. Many limestones crinoidal. Toward base limestone somewhat argillaceous. Reeflike bodies very common toward base. Reefs very fossiliferous. Limestone layers separated by thin shale layers. Shales thicker and more abundant toward base. Fauna of shales rich and varied.	*Enterolasma caliculum* *Dimerocrinus liliiformis* *Ichthyocrinus laevis* *Stephanocrinus gemmiformis* *Spatiopora maculata* *Chilotrypa ostiolata* *Eridotrypa striata* *Chasmatopora asperatostriata* *Pseudohornera diffusa* *Semicoscinium tenuiceps* *Rhinopora verrucosa* *Schizotreta tenuilamellata* *Dalmanella elegantula* *Orthis flabellites* *O. tenuidens* *Bilobites biloba*

	Most of fossils listed are from shales. Formation grades downward into underlying lowest layer about 2100 ft. south of road (east-west road leading from Alton-Sodus Point road through Alasa Farms).	*Leptaena rhomboidalis* *Sowerbyella transversalis* *Schuchertella subplana* *S. tenuis* *Stropheodonta convexa* *S. subplana* *Scenidium pyramidalis* *Dictyonella corallifera* *Camarotoechia obtusiplicata* *Atrypa gibbosa* *A. nodostriata* *A. reticularis* *A. rugosa* *Atrypina disparilis* *Cyrtia meta* *Reticularia bicostata* *Spirifer eudora* *S. niagarensis* *S. repertus* *S. sulcatus* *Trematospira camura* *Nucleospira pisiformis* *Whitfieldella cylindrica* *W. intermedia* *W. naviformis* *W. nitida* *Pterinea emacerata* *Conularia niagarensis* *Dawsonoceras annulatum* *Dalmanites limulurus* *Mastigobolbina punctata* *M. trilobata* *M. typus* *Plethobolbina typicalis*
19 ft. 4 in.	Dark gray, crumbly, pyritic, calcareous shale. Argillaceous limestone layers in upper part. When weathered yellowish in color due to pyrite. Grades downward into underlying shale. Contact about 1300 ft. south of road.	*Semicoscinium tenuiceps* *Orthis tenuidens* *Bilobites biloba* *Leptaena rhomboidalis* *Sowerbyella transversalis* *Chonetes cornutus* *Scenidium pyramidalis* *Clorinda fornicata* *Atrypa reticularis* *A. rugosa* *Cyrtia exporrecta myrtia* *Cyrtia meta* *Orthoceras abruptum* *Encrinurus ornatus* *Calymene clintoni* *Dalmanites limulurus* *Phacops trisulcatus* *Mastigobolbina punctata* *M. trilobata* *M. typus* *Plethobolbina typicalis* *Beyrichia aff. lakemontensis* ***Dibolbina* n. sp.**
	Williamson Shale	
18 ft. 3 in.	Dark greenish gray, fissile, pyritic shale. Near base much darker in color with graptolites as	*Retiolites geinitzianus venosus* *Monograptus clintonensis* *Dalmanella elegantula* *Orthis flabellites*

	the only fossils. In the lowest part pyrite very abundant forming layers sometimes a half-inch thick. Contact sharp and located 365 ft. south of bridge on east-west road leading from Sodus Point - Alton road through the Alasa Farms.	*O. tenuidens* *Stropheodonta corrugata* *Leptaena rhomboidalis* *Sowerbyella transversalis* *Scenidium pyramidalis* *Atrypa reticularis* *Atrypina disparilis* *Cyrtia meta* *Spirifer radiatus* *Hormotoma subulata* *Conularia niagarensis* *Calymene clintoni* *Dalmanites limulurus* *Beyrichia aff. lakemontensis* *Dibolbina* n. sp. *Mastigobolbina punctata* *M. typus*
4 in.	Two in. of coarse to fine, dark gray, phosphatic sandstone underlain by 2 in. of conglomerate. The individual pebbles are about a centimeter in diameter. They are loosely cemented. Some of the pebbles are limestone and closely resemble the underlying limestone. Other pebbles consist of quartz and their origin is difficult to explain. The sandstone and conglomerate indicate the break between Upper and Lower Clinton.	
Lower Clinton		
	Wolcott Furnace Iron Ore	
1 ft. 6 in.	Dark bluish gray calcareous shale with hematite. The basal 6 in. is composed largely of oolitic hematite. The upper part is dominantly a shale with oolites of hematite scattered through it. In this part oolites are commonly concentrated in bedding planes. The upper 6 in. is a solid mass of bryozoa. Grades into the underlying formation. Lowest layer 315 ft. south of road.	*Fenestella tenuis* *Semicoscinium tenuiceps* *Phaenopora constellata*
	Wolcott Limestone	
14 ft. 9 in.	Light bluish gray, crystalline limestone with interbedded bluish gray shales. Shale layers	*Favosites favosideus* *Chaetetes lycoperdon* *Chasmatopora angulata* *Fenestella tenuis*

	abundant in upper 5 ft. and lower 3 ft. Grades downward into underlying shale. Lowest layers just north of bridge.	*Semicoscinium tenuiceps* *Platystrophia biforata* *Leptaena rhomboidalis* *Pentamerus oblongus* *Atrypa reticularis* *Coelospira hemispherica* *Zygobolba decora* *Mastigobolbina decora*

Upper Sodus Shale

17 ft. 5 in.	Green to greenish gray shale with thin layers of limestone. Limestone usually pearly layers, but other brachiopods and even gastropods form some limestone. In upper part some layers bluish gray in color. Shale well-exposed. Very fossiliferous. Coelospirae appear dwarf in uppermost layers. The lowest layers outcrop in cliff 990 ft. north of bridge.	*Rusophycus pudicum* *Chaetetes lycoperdon* *Helopora fragilis* *Nematopora raripora* *Phaenopora constellata* *P. ensiformis* *Stropheodonta corrugata* *Camarotoechia aequiradiata* *Coelospira hemispherica* *Ctenodonta lata* *Pterinea emacerata* *Holopea obsoleta* *Strophostylus ventricosus* *Tentaculites minutus* *Phacops trisulcata* *Zygobolba decora* *Z. inflata* *Z. intermedia* *Z. robusta* *Mastigobolbina incipiens* *M. retifera*

SODUS CREEK — SECTION 15

Town of Rose. County of Wayne. Small hamlet locally known as Glenmark. Rock outcrops on both sides of the bridge over Sodus creek on the road leading west from hamlet of North Rose.

Top

Lockport

15 ft.	Dark brownish gray, thin-bedded dolomite. Near the base the layers are sandy.	No fossils collected

Upper Clinton — Contact gradational

Rochester Shale

2 ft. 6 in.	Transition bed. Crystalline limestone bearing fossils common in underlying shale interbedded with both thin-bedded sandy dolomitic layers of the overlying dolomite and brownish gray shale like the underlying formation. Several 2 in. and 3 in. layers composed of Nucleospira pisiformis. Fossils are all	*Enterolasma caliculum* *Zaphrentis turbinata* *Cystiphyllum niagarense* *Favosites hisingeri* *F. pyriformis* *Ceramopora imbricata* *Polypora incepta* *Pholidops squamiformis* *Dalmanella elegantula* *Orthis punctostriata* *Rhipidomella hybrida* *Schuchertella elegans* *S. tenuis*

	confined to the crystalline layers or to thin beds of brownish gray shale resembling the underlying Clinton. The dolomitic layers bear no fossils. This zone located 1475 ft. south of bridge.	*Leptaena rhomboidalis* *Atrypa reticularis* *Reticularia bicostata* *Spirifer niagarensis* *Homoeospira apriniformis* *Nucleospira pisiformis* *Whitfieldella nitida* *Diaphorostoma niagarense* *Conularia longa* *Proetus stokesi* *Arctinurus nereus* *Calymene niagarensis* *Dalmanites limulurus* *Paraechmina postica* *P. spinosa* *Dizygopleura proutyi* *Beyrichia veronica*
25 ft. 2 in.	Bluish gray, slightly dolomitic, calcareous shale with numerous tough, argillaceous limestone layers and a few medium gray, crystalline, thin, fossiliferous layers.	*Enterolasma caliculum* *Zaphrentis turbinata* *Cystiphyllum niagarense* *Favosites pyriformis* *Ceramopora imbricata* *Mesotrypa nummiformis* *Chasmatopora asperatostriata* *Acanthoclema asperum* *Dalmanella elegantula* *Rhipidomella hybrida* *Leptaena rhomboidalis* *Sowerbyella transversalis* *Schuchertella elegans* *S. subplana* *S. tenuis* *Stropheodonta profunda* *Camarotoechia neglecta* *Atrypa nodostriata* *A. reticularis* *A. rugosa* *Spirifer crispatus* *S. niagarensis* *S. radiatus* *S. sulcatus* *Trematospira camura* *Whitfieldella naviformis* *W. nitida* *Diaphorostoma hemisphericum* *Platyceras niagarense* *Homalonotus delphinocephalus* *Dalmanites limulurus* *Paraechmina postica* *P. spinosa* *Dizygopleura proutyi* *Beyrichia veronica*
10 ft. 5 in.	Dark gray, calcareous, tough shales and argillaceous limestones. Fossils not so abundant as in overlying strata. Fifteen in. argillaceous limestone at top caps falls.	*Enterolasma caliculum* *Mesotrypa nummiformis* *Dalmanella elegantula* *Rhipidomella hybrida* *Leptaena rhomboidalis* *Schuchertella subplana* *S. tenuis* *Camarotoechia neglecta* *Atrypa reticularis* *Spirifer niagarensis*

		S. radiatus *Platyceras niagarense* *Dalmanites limulurus* *Paraechmina spinosa*
4 ft.	Dark brownish gray, calcareous, tough shale with dark gray, argillaceous limestone layers. No fossils found. Lowest layer about 250 ft. north of bridge.	

BEAVER CREEK SECTION 16

Town of Huron. County of Wayne. West branch of Beaver creek north of United States Highway 104. There are several isolated outcrops on this branch but only one seems of sufficient note to warrant description.

Top

Upper Clinton

Rochester Shale

18 ft. 10 in.	Dark bluish gray shale somewhat calcareous. Some layers have a brownish color. Ostracods were found to within 4 ft. 6 in. of the base. Contact sharp and 3150 ft. south of United States Highway 104.	*Enterolasma caliculum* *Fenestella elegans* *Chaetetes lycoperdon* *Dimerocrinus liliiformis* *Lecanocrinus macropetalus* *Acanthoclema asperum* *Dalmanella elegantula* *Sowerbyella transversalis* *Schuchertella subplana* *S. tenuis* *Strophеodonta profunda* *Camarotoechia neglecta* *C. obtusiplicata* *Atrypa reticularis* *Homoeospira apriniformis* *Nucleospira pisiformis* *Whitfieldella cylindrica* *W. nitida* *Pterinea emacerata* *Dawsonoceras annulatum* *Homalonotus delphinocephalus* *Dalmanites limulurus* *Paraechmina postica* *P. spinosa*

Irondequoit Limestone

6 ft. 8 in.	Light gray, crystalline limestone with prominent shale partings. Thickness of shales increase downward. Reef-like bodies common. Limestone layers fossiliferous. Shale and reefs very fossiliferous with much greater variety of	*Enterolasma caliculum* *Favosites pyriformis* *Lecanocrinus macropetalus* *Stephanocrinus gemmiformis* *Chilotrypa ostiolata* *Mesotrypa nummiformis* *Chasmatopora asperatostriata* *Semicoscinium tenuiceps* *Rhinopora verrucosa* *Stictotrypa punctipora*

	fossils. Grades downward into underlying shale.	*Dalmanella elegantula* *Bilobites biloba* *Leptaena rhomboidalis* *Sowerbyella transversalis* *Schuchertella subplana* *S. tenuis* *Stropheodonta deflecta* *S. profunda* *Clorinda fornicata* *Camarotoechia neglecta* *Atrypa nodostriata* *A. reticularis* *Atrypina disparilis* *Reticularia bicostata* *Spirifer eudora* *S. niagarensis* *S. radiatus* *Whitfieldella cylindrica* *W. intermedia* *W. nitida* *Pterinea emacerata* *Conularia niagarensis* *Dawsonoceras annulatum* *Dalmanites limulurus* *Mastigobolbina punctata* *M. typus* *Dibolbina* n. sp.
7 ft.	Bluish gray, calcareous shale with a few limestone layers. Badly weathered and hard to obtain good fossils because of this. Probably contains more fossils than listed.	*Dalmanella elegantula* *Bilobites biloba* *Leptaena rhomboidalis* *Chlorinda fornicata* *Atrypa reticularis* *Spirifer radiatus* *Whitfieldella cylindrica* *W. nitida* *Mastigobolbina punctata* *M. trilobata*

Mudge Creek — Section 17

Town of Huron. County of Wayne. Outcrops both above and below the first bridge across Mudge creek south of North Huron. There are other outcrops on Mudge creek, but they are isolated and too small to be of importance.

Top

Lower Clinton

Wolcott Limestone

8 ft. 9 in.	Light gray limestone. Some layers crystalline. Thin light bluish gray calcareous shale common. Pentamerus mostly in crystalline limestone. Some shales bear bryozoans, others Coelospira. Ostracods most abundant in shales with Coelospira. Coelospira appear	*Chaetetes lycoperdon* *Chasmatopora angulata* *Fenestella tenuis* *Semicoscinium tenuiceps* *Helopora fragilis* *Nematopora raripora* *Phaenopora ensiformis* *Pachydictya crassa* *Rhipidomella circulus* *Stropheodonta corrugata* *Pentamerus oblongus*

	dwarfed in some layers. Contact gradational and 400 ft. downstream from bridge.	*Camarotoechia neglecta* *Atrypa reticularis* *Spirifer radiatus* *Cornulites distans* *Calymene niagarensis* *Mastigobolbina incipiens* *M. retifera* *Zygobolba decora*

Upper Sodus Shale

8 ft. 9 in.	Greenish gray and bluish gray calcareous shales with limestone layers composed of Coelospira. Coelospira dwarf in shale layers at top. The whole section is exposed 850 ft. below the bridge in a small cliff.	*Helopora fragilis* *Nematopora raripora* *Phaenopora ensiformis* *Dalmanella elegantula* *Rhipidomella circulus* *Stropheodonta corrugata* *Rhynchotreta robusta* *Atrypa reticularis* *Coelospira hemispherica* *Pterinea emacerata* *Strophostylus ventricosus* *Cornulites distans* *C. flexuosus* *Calymene niagarensis* *Zygobolba decora* *Z. inflata* *Z. intermedia* *Z. robusta* *Mastigobolbina incipiens* *M. retifera*

Wolcott Creek — Section 18

Town of Wolcott. County of Wayne. Within the village rock outcrops in gorge north of mill pond. This is an excellent section of the middle portion of the Rochester. Wolcott creek exposes the lower formations but the outcrops are so small and badly weathered that they are not included.

Top

Upper Clinton

Rochester Shale

34 ft.	Brownish gray, calcareous shale with abundant dark brownish gray, argillaceous limestone layers. Limestones dominate in upper part. One layer particularly resistant 5 ft. 3 in. thick forms cap of Wolcott falls. Fossils comparatively rare. Many layers barren. Grades into underlying shale.	*Enterolasma caliculum* *Dalmanella elegantula* *Sowerbyella transversalis* *Leptaena rhomboidalis* *Stropheodonta profunda* *Atrypa reticularis* *Spirifer radiatus* *Platyceras niagarensis* *Homalonotus delphinocephalus* *Dalmanites limulurus*

22 ft. 9 in.	Brownish gray, calcareous shale with very few argillaceous limestones. Fossils abundant. Some layers filled with them. Whitfieldella cylindrica very common in lowest layers exposed in stream bed. Fossils of this species making up the major part of some layers. Lowest layer outcrops in stream bed 525 ft. downstream from falls.	*Favosites hisingeri* *Mesotrypa nummiformis* *Chasmatopora asperatostriata* *Pholidops squamiformis* *Dalmanella elegantula* *Rhipidomella hybrida* *Sowerbyella transversalis* *Schuchertella subplana* *Stropheodonta profunda* *Leptaena rhomboidalis* *Camarotoechia neglecta* *C. obtusiplicata* *Atrypa nodostriata* *A. reticularis* *Spirifer radiatus* *S. sulcatus* *Whitfieldella cylindrica* *W. nitida* *W. nitida oblata* *Pterinea emaccrata* *Platyceras niagarense* *Proetus corycocus* *Homalonotus delphinocephalus* *Dalmanites limulurus* *Paraechmina postica* *P. spinosa* *Dizygopleura proutyi* *Beyrichia veronica*

Little Wolcott Creek — Section 19

Town of Wolcott. County of Wayne. The creek is unnamed on the topographic map. It flows east of and parallel with Wolcott creek. The first outcrop on this creek is near the railroad bridge (Rome, Watertown and Ogdensburg Division of the New York Central). The Rochester part of the section is so poorly exposed that it will not be described. North of the second cross road north of the village of Wolcott the outcrops are more continuous and not so badly weathered.

Top

Upper Clinton

Irondequoit Limestone

5 ft. 6 in.	Bluish gray limestone. Some layers crystalline but mostly argillaceous with a dull gray color. The upper layer has reeflike bodies. The shale partings have the greatest fauna. The highest layer outcrops 1200 ft. downstream from the cross road. Lower limit very arbitrary.	*Mesotrypa nummiformis* *Chasmatopora asperatostriata* *Fenestella elegans* *Semicoscinium tenuiceps* *Dalmanella elegantula* *Orthis flabellites* *O. tenuidens* *Bilobites biloba* *Leptaena rhomboidalis* *Sowerbyella transversalis* *Schuchertella subplana* *S. tenuis* *Stropheodonta profunda* *Chlorinda fornicata* ***Atrypa nodostriata***

		A. reticularis *A. rugosa* *Atrypina disparilis* *Spirifer eudora* *S. niagarensis* *S. radiatus* *S. sulcatus* *Cyrtina pyramidalis* *Trematospira camura* *Nucleospira pisiformis* *Whitfieldella cylindrica* *W. intermedia* *Cuneamya alveata* *Leptodesma rhomboidea* *Leiopteria subplana* *Pterinea emacerata* *Platyceras niagarense* *Cornulites distans* *Orthoceras abruptum* *Dawsonoceras annulatum* *Proetus corycocus* *P. stokesi* *Calymene clintoni* *C. niagarensis* *Homalonotus delphinocephalus* *Dalmanites limulurus* *Mastigobolbina punctata* *M. trilobata* *Plethobolbina typicalis* *Dizygopleura intermedia cornuta*
10 ft. 5 in.	Upper part bluish gray, argillaceous limestone dominates. Lower part bluish gray, crumbly, calcareous shale dominates. Ostracods common. Other fossils rare. Highest layer 1450 ft. north of bridge.	*Dalmanella elegantula* *Bilobites biloba* *Leptaena rhomboidalis* *Sowerbyella transversalis* *Chonetes cornutus* *Chlorinda fornicata* *Atrypa gibbosa* *A. reticularis* *Dawsonoceras annulatum* *Calymene clintoni* *Mastigobolbina punctata* *M. trilobata* *M. typus* *Plethobolbina typicalis* *Beyrichia aff. lakemontensis*
22 ft.	Dark bluish gray, calcareous, crumbly shale. Weathers a yellow limonitic color. Pyrite abundant in fresh rock. Highest layer 2550 ft. north of bridge. Lowest 1500 ft. south of point where Port Bay road crosses creek.	*Bilobites biloba* *Leptaena rhomboidalis* *Schuchertella subplana* *Chonetes cornutus* *Chlorinda fornicata* *Atrypa reticularis* *Spirifer radiatus* *Dawsonoceras annulatum* *Calymene clintoni* *Dalmanites limulurus* *Mastigobolbina punctata* *M. trilobata* *M. typus* *Plethobolbina typicalis* *Beyrichia aff. lakemontensis* *Dibolbina* n. sp.

5 ft.	**Green** fissile shale. Shale exposed on downthrown side of a fault. The fault is 920 ft. south of Port Bay road. The fault may be seen in a small cliff on the west side of the valley. The fault shows **about 15 ft.** of displacement.	*Chaetetes lycoperdon* *Retiolites geinitzianus venosus* *Monograptus clintonensis* *Rhipidomella hybrida* *Sowerbyella transversalis* *Stropheodonta corrugata* *Chonetes cornutus* *Scenidium pyramidale* *Atrypa nodostriata* ***A. reticularis*** ***Spirifer eudora*** ***S. radiatus*** *Coelospira sulcata* *Calymene clintoni* *Mastigobolbina punctata* *M. trilobata* *M. typus* *Beyrichia aff. lakemontensis* ***Dibolbina*** n. sp.

Lower **Clinton**

Wolcott Limestone

10 ft. 6 in.	Light bluish gray, crystalline limestone. Shale layers common. This limestone on upthrown side of fault. Shale becomes more abundant toward base. Grades to underlying shale. The lowest layer of limestone is 310 ft. south of road.	*Zaphrentis bilateralis* *Fenestella tenuis* *Semicoscinium tenuiceps* *Helopora fragilis* *Phaenopora ensiformis* *Platystrophia biforata* *Rhipidomella circulus* *Stropheodonta corrugata* *Chonetes cornutus* *Pentamerus oblongus* *Camarotoechia neglecta* *Coelospira hemispherica* *Mastigobolbina incipiens* *M. retifera* *Zygobolba decora*

Upper Sodus Shale

2 ft.	Greenish gray and light bluish gray shale with a limestone lens of Coelospira. Coelospirae appear dwarfed. Poor outcrop. All rock exposed in stream bed.	*Phaenopora constellata* *P. ensiformis* *P. explanata* *Helopora fragilis* *Stropheodonta corrugata* *Coelospira hemispherica* *Strophostylus ventricosus* *Holopea obsoleta* *Cornulites distans* *Zygobolba decora* *Z. inflata* *Z. intermedia* *Z. robusta* ***Mastigobolbina incipiens*** *M. retifera*

NORTH WOLCOTT — SECTION 20

Town of Wolcott. County of Wayne. Little Red creek flows into Red creek. The first outcrop occurs 1525 feet north of the four **corners at North Wolcott.**

Top

Lower Clinton

Thorold Sandstone

4 ft. 3 in.	Light gray sandstone with small pellets of embedded shale. Some layers calcareous. Deeply weathered. Weathering causes formation to first break into rectangular pieces, then crumble into white sandy soil. Contact sharp and located 1675 ft. north of four corners.	*Arthrophycus alleghaniensis*

Albion Group

Grimsby Sandstone

15 ft.	Red sandstone. Tightly cemented, very resistant red sandstone. Many conglomeratic layers in upper part.	*Arthrophycus alleghaniensis*

BEAR CREEK SECTION 21

Town of Wolcott. County of Wayne. Rock is exposed on a small tributary of Black creek which is locally known as Bear creek. This tributary enters Black creek a short distance to the north of where the southwest road from Fair Haven crosses Black creek. That part of the section which is below the ore is poorly exposed and was uncovered by digging. The part of the section above the ore is well exposed, not only in the stream bed of Bear creek but also in the old ore pits just to the north of the stream. The ore pits are known as the Devoe ore pits. This is the type section of the Bear creek.

Top

Lower Clinton

Lower Sodus Shale

10 ft 5 in.	Dark gray or purple shale. Some green shale. A few sandy layers. Very fossiliferous. Contact sharp.	*Buthotrephis gracilis* *Chaetetes lycoperdon* *Phaenopora ensiformis* *Heloplora fragilis* *Strophcodonta corrugata* *Coelospira hemispherica* *Tentaculites minutus* *Zygobolba curta* *Z. excavata* *Z. prolixa* *Z. rectangula*

	Bear Creek Shale	
3 in.	Oolitic hematitic limestone. Grades downward into underlying limestone.	*No fossils collected*
8 in.	Dark gray, argillaceous, slightly sandy limestone. Upper part hematitic. Few fossils.	*Coelospira hemispherica*
5 ft.	Dark gray or purple, pyritic shale with thin argillaceous, pyritic limestones near top and middle. Pelecypods very abundant.	*Chaetetes lycoperdon* Crinoid stems *Helopora fragilis* *Phaenopora ensiformis* *P. clintoni* *Lingula oblata* *L. perovata* *Stropheodonta corrugata* *Rhynchonella emacerata* *Coelospira hemispherica* *Ctenodonta lata* *C. machaeriformis* *C. mactriformis* *Pyrenomoeus cuneatus* *Cyrtodonta alata* *Pterinea emacerata* *Modiolopsis subalatus* *Orthodesma curtum* *Tentaculites minutus* *Zygobolba curta* *Z. excavata* *Z. prolixa* *Z. rectangula*
7 in.	Dark gray, argillaceous limestone layer.	Crinoid stems *Coelospira hemispherica*
6 ft. 10 in.	Dark gray or purple pyritic shales with alternating dark gray, argillaceous, pyritic limestones. Contact sharp.	*Coelospira hemispherica* *Ctenodonta machaeriformis* *Pterinea emacerata* *Zygobolba curta* *Z. excavata* *Z. prolixa* *Z. rectangula*
	Furnaceville Iron Ore	
20 in.	Oolitic, fossiliferous, hematitic limestone. Contact gradational.	*Helopora fragilis* *Phaenopora ensiformis* *P. explanata* *Coelospira hemispherica* *Zygobolba curta* *Z. excavata* *Z. rectangula*
	Thorold Sandstone	
8 in.	Alternating shale and limestone and sandy shale. Fossils rare and poorly preserved.	*Stropheodonta corrugata* *Coelospira hemispherica*
2 ft.	Covered	
2 ft.	Gray sandstone. Poorly preserved.	

BLIND SODUS CREEK SECTION 22

Town of Sterling. County of Cayuga. Outcrop located on main branch of Blind Sodus creek one and one-half miles east of the village of Red Creek on the improved Red Creek-Sterling Station road. It is the third stream shown crossing the road east of Red Creek. Rock is exposed both to north and south of road. Main outcrops are to the north.

Top

Upper Clinton

Rochester Shale

12 ft. 9 in.	Brownish gray, calcareous shale very poorly exposed except basal 5 ft. Lowest layer outcrops 115 ft. north of road. **Contact sharp.**	*Enterolasma caliculum* *Mesotrypa nummiformis* *Chasmatopora asperostriata* *Fenestella elegans* *Rhinopora verrucosa* *Dalmanella elegantula* *Sowerbyella transversalis* *Schuchertella subplana* *S. tenuis* *Stropheodonta profunda* *Leptaena rhomboidalis* *Spirifer niagarensis* *S. radiatus* *Whitfieldella naviformis* *W. nitida* *Pterinea emacerata* *P. undata* *Cypricardinia undulostriata* *Orthoceras abruptum* *Proetus stokesi* *Arctinurus nereus* *Homalonotus delphinocephalus* *Dalmanites limulurus* *Paraechmina spinosa* *Dizygopleura proutyi*

Irondequoit Limestone

18 ft. 9 in.	Gray, calcareous shale with many limestone layers. Most limestone argillaceous with some fossils A few crystalline crinoidal layers in upper 5 ft. Reeflike bodies in upper 5 ft. Most shale crumbly and weathers rust colored. Some thin bedded. Graptolites at two horizons, one 4½ ft. from top, the other near base. Ostracods very abundant in layer 6 in. below top. Contact gradational and 800 ft. downstream from bridge.	*Enterolasma caliculum* *Dictyonema subretiforme* *Mesotrypa nummiformis* *Fenestella elegans* *Rhinopora verrucosa* *Dalmanella elegantula* *Rhipidomella hybrida* *Sowerbyella transversalis* *Leptaena rhomboidalis* *Schuchertella subplana* *S. tenuis* *Stropheodonta profunda* *Camarotoechia neglecta* *Atrypa gibbosa* *A. reticularis* *Atrypina disparilis* *Spirifer niagarensis* *S. radiatus* *Whitfieldella cylindrica*

		W. intermedia *Pterinea emacerata* *Amphicoelia orbiculoides* *Dawsonoceras annulatum* *Mastigobolbina typus* *Plethobolbina typicalis*
13 ft. 6 in.	Bluish gray shale, some calcareous, some fissile. No limestone layers. Graptolites found throughout but not abundantly. Fossils comparatively rare. Lowest layer about 1200 ft. downstream from road.	*Monograptus clintonensis* *Bilobites biloba* *Leptaena rhomboidalis* *Sowerbyella transversalis* *Atrypa reticularis* *Spirifer niagarensis* *S. radiatus* *Whitfieldella cylindrica* *W. intermedia* *W. naviformis* *W. nitida* *Dawsonoceras annulatum* *Mastigobolbina punctata* *M. trilobata* *M. typus* *Plethobolbina typicalis*

Sterling Station

Section 23

Town of Sterling. County of Cayuga. In the past iron ore has been mined at Sterling Station. In the mining of this ore a considerable amount of rock has been uncovered. There are three major openings all located to the west of Sterling Station, near the first four corners in that direction. One is situated just northwest of these corners, another to the southeast of the corners, and still another, the most recent, is east of the railroad (New York Central: Rome, Watertown and Ogdensburg Division). Only two of these openings will be described in detail.

Opening northwest of the first four corners. Oldest pit in the area. Because the pits are filled with water and the sides overgrown, no good opportunity is given to study the section above the ore. On the small streams to the west of the openings the rock underlying the ore is exposed.

Top

Lower Clinton

Thorold Sandstone

5 ft. 8 in.	Light gray slightly calcareous sandstone with embedded green shale pellets. The upper part very shaly and light greenish gray in color. Evidently rock directly underlies ore. Contact gradational.	*Arthrophycus alleghaniensis*

Albion Group

Grimsby Sandstone

3 ft.+	Red sandstone with light green blotches. Some conglomeratic layers.	*Arthrophycus alleghaniensis*

Opening east of railroad. The rock above the ore is well exposed east of railroad in the most recent workings.

Lower Clinton

Lower Sodus Shale

7 ft. 6 in.	Dark greenish gray shale with thin limestone layers. Some thin sandy layers noted. Fossils often preserved as limonitic casts. Contact sharp.	*Helopora fragilis* *Phaenopora ensiformis* *Lingula perovata* *Stropheodonta corrugata* *Coelospira hemispherica* *Pterinea emacerata* *Tentaculites minutus* *Zygobolba curta* *Z. excavata* *Z. inflata* *Z. prolixa*

Bear Creek Shale

3 in.	Hematitic, oolitic limestone. No fossils. Contact gradational.	
7 in.	Gray, sandy limestone. Upper part hematitic. Fossils rare. Two *Pentamerus oblongus* found. Fossil burrows or trails found in basal part. Closely resemble Arthrophycus. Contact sharp.	*Arthrophycus alleghaniensis* *Lingula perovata* *Coelospira hemispherica* *Pentamerus oblongus* *Tentaculites minutus*
1 ft. 6 in.	Dark gray or purple shale. Thin crystalline limestone. Coelospira.	*Helopora fragilis* *Phaenopora ensiformis* *P. explanata* *Stropheodonta corrugata* *Coelospira hemispherica* *Encrinurus ornatus* *Zygobolba curta* *Z. excavata* *Z. inflata* *Z. prolixa*
4 ft. 6 in.	Dark gray or purple shale with few limestone layers. Lower part poorly exposed. Pelecypods very abundant.	*Helopora fragilis* *Phaenopora ensiformis* *Lingula clintoni* *L. oblata* *L. perovata* *Stropheodonta corrugata* *Coelospira hemispherica* *Ctenodonta elliptica* *C. machacriformis* *C. mactriformis* *Pyrenomoeus cuneatus* *Pterinea emacerata*

		Modiolopsis subalata *Tentaculites minutus* *Zygobolba curta* *Z. elongata ?* *Z. excavata* *Z. inflata* *Z. prolixa*
5 ft.	Covered with water. Thickness from records of engineers.	

Furnaceville Iron Ore

2 ft. 6 in.	Red hematitic, oolitic limestone. Fossils rare. Covered with water. Thickness from records of engineers. Fossils from ore dump.	*Zaphrentis bilateralis* *Helopora fragilis* *Phaenopora ensiformis* *Coelospira hemispherica* *Tentaculites minutus* *Zygobolba curta*

LITTLE SODUS CREEK — SECTION 24

Town of Victory. County of Cayuga. Rock outcrops where stream crosses the road leading south from North Victory near the southern boundary of the Oswego quadrangle. Rock is exposed 200 feet upstream from bridge and 1350 feet downstream.

Top

Upper Clinton

Rochester Shale

22 ft. 6 in.	Dark brownish gray shale. Some layers calcareous. Few thin sandstone layers. 3 in. hematitic layer near middle. Fossiliferous. Whole section exposed but not continuously.	*Favosites hisingeri* *Dictyonema gracilis* *Ceramopora imbricata* *Mesotrypa nummiformis* *Chasmatopora asperatostriata* *Fenestella elegans* *Semicoscinium tenuiceps* *Rhinopora verrucosa* *Dalmanella elegantula* *Orthis flabellites* *Rhipidomella hybrida* *Leptaena rhomboidalis* *Sowerbyella transversalis* *Schuchertella subplana* *S. tenuis* *Strophеodonta profunda* *Camarotoechia neglecta* *C. obtusplicata* *Atrypa reticularis* *Spirifer niagarensis* *S. radiatus* *Whitfieldella nitida* *Pterinea emacerata* *Cypricardinia undulostriata* *Diaphorostoma hemisphericum* *Homalonotus delphinocephalus* *Dalmanites limulurus* *Paraechmina postica* *P. spinosa* *Dizygopleura proutyi*

MARTVILLE (LUNN'S QUARRY) SECTION 25

Town of Hannibal. County of Oswego. Lower part of section exposed in an old quarry locally known as Lunn's which is situated 500 feet south of first four corners southwest of Hannibal on United States Highway 104. The rest of the section outcrops on a small tributary of Sterling Valley creek which flows west through the quarry to enter the main stream.

Top

Lower Clinton

Lower Sodus Shale

19 ft. 10 in.	Green and dark purplish gray shale interbedded. In the basal part the purplish shale predominates. In the upper part the green predominates. Some thin limestone layers. Pelecypods abundant in lower part. They are restricted for the most part to definite layers. Not many other fossils associated with them. Contact sharp.	*Chaetetes lycoperdon* *Dictyonema gracilis* *Dendocrinus longidactylus* *Helopora fragilis* *Phaenopora ensiformis* *Stropheodonta corrugata* *Coelospira hemispherica* *Ctenodonta machaeriformis* *Pyrenomoeus cuneatus* *Pterinea emacerata* *Modiolopsis subalata* *Holopea obsoleta* *Tentaculites minutus* *Cornulites distans* *Encrinurus ornatus* *Phacops triculcatus* *Zygobolba curta* *Z. excavata* *Z. inflata* *Z. prolixa* *Z. rectangula*

Bear Creek Shale

3 in.	Red oolitic, hematitic limestone. Grades downward into underlying. No fossils observed.	
11 ft. 3 in.	Dark gray or purple shale. Calcareous layers common. Few argillaceous dark gray limestones. Stringers of hematite in upper 18 in. and in lower 30 in. Thin sandy layers common throughout. Pelecypods abundant. Ostracods very common and often replaced by limonite. Contact not well-defined.	*Helopora fragilis* *Phaenopora ensiformis* *Lingula clintoni* *L. oblata* *L. perovata* *Pholidops squamiformis* *Stropheodonta corrugata* *Coelospira hemispherica* *Ctenodonta machaeriformis* *C. mactriformis* *Pyrenomoeus cuneatus* *Modiolopsis subalatus* *Tentaculites minutus* *Zygobolba curta* *Z. excavata* *Z. prolixa*

Furnaceville Iron Ore

1 ft. 6 in.	Argillaceous, hematitic limestone with many shale layers. Upper 4 in. contains considerable hematite. Very pyritic near middle. Fossils rare and poorly preserved. Contact not sharp.	*Helopora fragilis* *Phaenopora ensiformis* *Stropheodonta corrugata* *Coelospira hemispherica* *Tentaculites minutus* *Zygobolba curta* *Z. excavata* *Z. prolixa*

Thorold Sandstone

7 ft. 5 in.	Gray calcareous sandstone with interbedded green shale layers. Phosphatic nodules common especially in central part. Conglomeratic layer about 3 ft. 6 in. from top. Lower 2 ft. 6 in. gray sandstone with embedded clay pellets. Arthrophycus in basal part. Lingula in upper. Ostracods in green shale breaks. Very poorly preserved.	*Arthrophycus alleghaniensis* *Lingula clintoni* *L. oblata* *L. perovata* *Zygobolba curta?* *Z. prolixa?*

Albion Group

Grimsby Sandstone

4 ft.	Red sandstone. Some layers contain green blotches.	*Arthrophycus alleghaniensis*

STERLING VALLEY CREEK — SECTION 26

Town of Hannibal. County of Oswego. Rock is found in stream bed north of first four corners east of Martville on the Martville-Hannibal Center road. The exposure is immediately west of mill pond (no longer in existence) shown on topographic map.

Top

Lower Clinton

Upper Sodus Shale

10 ft. 6 in.	Green shale with limestone layers. Limestone crystalline. Some entirely composed of Coelospira. The highest layers outcrop at the millpond, the lowest 735 ft. to the west.	*Helopora fragilis* *Phaenopora ensiformis* *P. explanata* *Leptaena rhomboidalis* *Stropheodonta corrugata* *Atrypa reticularis* *Coelospira hemispherica* *Pterinea emacerata* *Pyrenomoeus cuneatus* *Tentaculites minutus* *Calymene niagarensis* *Zygobolba decora* *Z. intermedia* *Z. robusta* *Mastigobolbina incipiens* *M. retifera*

OSWEGO RIVER SECTION 27

Towns of Volney and Granby. County of Oswego. Outcrop is located within the limits of the city of Fulton, just south of Broadway bridge.

Top

Lower Clinton

Oneida Conglomerate

12 ft. 9 in.	White sandstone with conglomeratic layers. Some green shale layers. Some layers slightly calcareous near center of formation. This portion finer-grained with embedded shale pellets.	*Arthrophycus alleghaniensis*

Albion Group

Grimsby Sandstone

8 ft.	Red sandstone. Cross-bedded. Many layers very argillaceous, Some even sandy shales.	*Arthrophycus alleghaniensis*

PHOENIX SECTION 28

Town of Schroeppel. County of Oswego. Within the village of Phoenix rock forms the bed of the Oswego branch of the Barge canal. When the original excavation was made for the canal, the rock taken from the canal was piled up on the east bank in the extreme northwestern part of the village limits. During the summer of 1935 the canal bed was lowered near the locks at Phoenix. Fossil collections were made from the dump and from the dredge. The engineers working on the dredge furnished data showing that the section excavated was about 20 feet thick. A comparison of the lithology of these rocks with that of the rock of the diamond drill core from South Granby about five miles west shows that these rocks are part of the uppermost Williamson. The dark bluish crumbly shale suggests that some of the lowest Irondequoit may be represented. The absence of *Plethobolbina typicalis* and the presence of *Dibolbina* n. sp. and *Beyrichia* aff. *lakemontensis* argues for a Williamson age of the whole section.

Top

Upper Clinton

Williamson Shale

20 ft.	Green fissile shale interbedded with dark bluish gray crumbly shale. Limestone layers are common. Some are com-	*Buthotrephis gracilis* *Enterolasma caliculum* *Dictyonema gracilis* *D. retiforme* *Retiolites geinitzianus venosus*

posed entirely of Sowerbyella, some largely of Atrypa, others contain a variety of fossils. Still others are crystalline with no fossils. Graptolites confined to green fissile shales. Ostracods most plentiful in dark bluish gray calcareous shale.	*Monograptus clintonensis* *Pholidops squamiformis* *Dalmanella elegantula* *Orthis tenuidens* *Bilobites biloba* *Leptaena rhomboidalis* *Sowerbyella transversalis* *Stropheodonta corrugata* *Chonetes cornutus* *Scenidium pyramidale* *Rhynchonella bidens* *Atrypa nodostriata* *A. reticularis* *Atrypina disparilis* *Cyrtia meta* *Spirifer radiatus* *Coelospira sulcata* *Ctenodonta mactriformis* *Hormotoma subulata* *Orthoceras bassleri* *Calymene clintoni* *Dalmanites limulurus* *Mastigobolbina punctata* *M. trilobata* *M. typus* *Beyrichia aff. lakemontensis* *Dibolbina* n. sp.

BREWERTON SECTION 29

Town of Cicero. County of Onondaga. Rock outcrops in the outlet to Oneida lake. This can be obtained only when the water is extremely low. Within the village limits the soft shale rock is found south of Oneida river, and all the road cuts expose layers of this shale. The shale in these road cuts is badly weathered. One of the best outcrops for collecting fossils is on United States Highway 11, 450 feet south of Oneida river. Another is located on the only road leading west from the village 425 feet west of the railroad. From the diamond drill core it appears that the lowest layers outcropping in the outlet of Oneida lake are within 10 feet of the base of the Williamson.

Top

Upper Clinton

Williamson Shale

45 ft.	Green fissile shale with minor limestone lenses. The shale abounds in pyrite. This pyrite weathers rapidly giving the whole outcrop a limonitic color. The layers which contain the greatest amount of pyrite are devoid of animal remains. In other layers the organisms appear to have been dwarfed by the	*Palaeocyclus rotuloides* *Enterolasma caliculum* *Dictyonema gracilis* *D. retiforme* *Retiolites geinitzianus venosus* *Monograptus clintonensis* *Lingula lamellata* *Bilobites biloba* *Leptaena rhomboidalis* *Sowerbyella transversalis* *Schuchertella subplana* *Chonetes cornutus* *Scenidium pyramidale*

pyritic conditions. The limestone layers are often unfossiliferous but a few are composed largely of fossils. Two such fossiliferous layers are made up of *Coelospira sulcata*. The thickness was determined by taking the elevation by means of a level of the lowest and highest layers outcropping.	*Camarotoechia acinus* *Atrypa reticularis* *Cyrtia meta* *Spirifer radiatus* *Coelospira sulcata* *Ctenodonta mactriformis* *Leptodesma rhomboideum* *Pterinea emacerata* *Cyclonema varicosum* *Calymene clintoni* *Dalmanites limulurus* *Mastigobolbina punctata* *M. trilobata* *M. typus* *Beyrichia aff. lakemontensis* *Dibolbina* n. sp.

ONEIDA LAKE BEACH — SECTION 30

Town of Sullivan. County of Madison. The outcrop is located half-way between Lakeport and the summer resort which is named Oneida Lake, on the topographic map. This part of the lake shore is now known as Oneida Lake beach. At this point the rock forms the beach of Oneida lake. Although only a small section is exposed at this point, its place in the section can be determined with some degree of accuracy. There are old Lockport quarries less than three-quarters of a mile to the south. The Rochester-Lockport contact was uncovered in a large drainage ditch which follows the course of Canaseraga creek, and is located immediately south of the bridge over this creek. These outcrops together with the diamond drill core, one and one-half miles northeast of Lakeport, show that the Oneida Lake beach outcrop must be about 30 feet below the top of the Rochester.

Top

Upper Clinton

Rochester Shale

6 ft. 9 in.	Gray, sandy, dolomitic limestone. Some layers are shaly. Stringers of hematite common, particularly near center. Crinoid stems form some of the more pure layers.	*Enterolasma caliculum* *Favosites hisingeri* *Leptaena rhomboidalis* *Schuchertella subplana* *Camarotoechia neglecta* *Spirifer radiatus* *Nucleospira pisiformis* *Whitfieldella nitida oblata* *Homalonotus delphinocephalus* *Dalmanites limulurus* *Paraechmina postica* *P. spinosa*

STONY CREEK — SECTION 31

Town of Verona. County of Oneida. There are a number of fragmentary outcrops on Stony creek and its tributaries. The one farthest south is located one and a half miles southwest of Verona

Station. The rock outcrops on both sides of a bridge over the stream. This bridge is on a road leading northwest from the main road between Verona and Oneida. It is the third road to lead westward, southwest of Verona. Old quarry located south of road.

Top

Upper Clinton

Herkimer Sandstone

50 ft.	Brownish gray sandstone with an abundance of bluish gray shale layers. Most sandstone layers are thin. Some have mud cracks, some bear the so-called plants. No continental sandstone discovered. Most of the fossils occur in the sandstones and are preserved as casts and molds.	*Paleophycus striatum* *Rusophycus biloba* *R. subangulatum* *Cladopora seriata* *Chilotrypa ostiolata* *Hallopora elegantula* *Clathropora frondosa* *Dalmanella elegantula* *Leptaena rhomboidalis* *Sowerbyella transversalis* *Rafinesquina obscura* *Schuchertella subplana* *Stropheodonta profunda* *Camarotoechia neglecta* *Atrypa reticularis* *Spirifer niagarensis* *S. radiatus* *Cuneamya alveata* *Leptodesma rhomboidea* *Pterinea emacerata* *Calymene niagarensis* *Arctinurus nereus* *Homalonotus delphinocephalus* *Dalmanites limulurus*

No exposures for one mile downstream. At that point rock outcrops in one of the branches of Stony creek. Taking into account the dip of the rock, which was computed as 64 feet to the mile (computed on the Oneida conglomerate outcrop and comparing test hole elevation with outcrop elevation) there is about 67 feet covered.

Top

Middle Clinton

Sauquoit Shale

21 ft.	Green sandy, fissile shale with sandstone members. Sandstones fine-grained. Pyrite very common. Both shales and sandstones fossiliferous. Ostracods very abundant in sandstone. Some of outcrops deeply weathered.	*Rhipidomella circulus* *Chonetes cornutus* *Coelospira hemispherica* *Cyrtodonta alata* *Pterinea emacerata* *Bucanella trilobata* *Cyclonema varicosum* *Kionoceras cancellatum* *Calymene clintoni* *Dalmanites (limulurus)?* *Chilobolbina hartfordensis* *Zygobolbina conradi* *Mastigobolbina clarkei* *M. lata* *M. lata* var. *nana* *M. vanuxemi*

Downstream Stony creek and its tributary again flow over glacial material for a mile and one-tenth. The next outcrop occurs eight-tenths of a mile northeast of Verona Station on the west side of the main line of the New York Central railroad, where it makes a slight bend. This location was once worked for iron ore. The pits themselves are filled with water. In a dry time the water level apparently stands about one foot and a half above the ore. (The writer obtained a piece of ore, which was thought to be in place, with the aid of a bar.) Besides the outcrop right at the pits higher layers of shale may be studied east of the pits near the railroad. Weathered specimens of very fossiliferous ore may be obtained from the dumps near the pits.

Sauquoit Shale

10 ft.	Bluish gray, thin-bedded, sandy shales with very sandy, thin limestones. Fossiliferous. Casts of ostracods abundant in weathered sandy limestone.	*Rhipidomella circulus* *Chonetes cornutus* *Atrypa reticularis* *Coelospira hemispherica* *Liocalymene clintoni* *Zygobolbina conradi* *Mastigobolbina clarkei* *M. lata* *M. vanuxemi*

Lower Clinton

Wolcott Furnace Iron Ore

1 ft. 5 in.	Red, fossiliferous, hematitic limestone. Thickness of this ore given by Newland and Hartnagel ('08, p. 67). Can not be accurately measured now.	*Zaphrentis bilateralis* *Fenestella tenuis* *Phaenopora constellata* *P. ensiformis* *P. explanata* *Dalmanella elegantula* *Leptaena rhomboidalis* *Rhynchotreta robusta* *Atrypa reticularis* *Coelospira hemispherica* *Encrinurus ornatus* *Zygobolba decora* *Z. oblonga* *Mastigobolbina incipiens* *M. retifera*

The rest of the Clinton above the Oneida conglomerate is very poorly exposed. Small isolated fragmentary outcrops of shale are found jutting out here and there from the southwest bank of a tributary to Stony creek flowing northwest about six-tenths of a mile northeast of Verona.

Upper Sodus Shale

Greenish shale with a few thin sandstone layers. One thin limestone was found in place. Some pieces of cherty limestone float observed.	*Zaphrentis bilateralis* *Favosites favosideus* *Chaetetes lycoperdon* *Chasmatopora angulata* *Fenestella tenuis* *Helopora fragilis*

Some shale very fossiliferous. Fossils more resistant than enclosing shale. Highest layer of outcropping shale about 10 ft. below ore pit located on the same stream.	*Phaenopora ensiformis* *Platystrophia biforata* *Leptaena rhomboidalis* *Stropheodonta corrugata* *Rhynchotreta robusta* *Atrypa reticularis* *Coelospira hemispherica* *Ctenodonta lata* *Pyrenomoeus cuneatus* *Pterinea emacerata* *Modiolopsis ovata* *Orthodesma curtum* *Orthoceras clavatum* *O. virgulatum* *Discosorus conoideus* *Actinoceras vertebratum* *Oncoceras subrectum* *Calymene senaria* *Calymenella rostrata* *Zygobolba decora* *Z. inflata* *Z. oblonga* *Z. robusta*

The Oneida conglomerate outcrops 300 feet north of the three corners, located one and a half miles due north of Verona. To the south of the massive conglomerate interbedded green shales and thin sandstones are found outcropping in the drainage ditch along the road. No attempt was made to measure the section. The following are lists of fossils found in the shales and sandstone.

From the shale layers.	*Zaphrentis bilateralis* *Helopora fragilis* *Phaenopora ensiformis* *Leptaena rhomboidalis* *Camarotoechia robusta* *Coelospira hemispherica* *Tentaculites minutus* *Zygobolba decora* *Z. inflata*
From the sandstone and conglomerate layers.	*Arthrophycus alleghaniensis*

College Hill Creek — Section 32

Town of Kirkland. County of Oneida. College Hill creek is the first stream shown on the topographic map which flows into Oriskany creek north of College Hill. The exposure is poor because so much of the course is covered by débris and because the stream is interrupted by dams.

Top

Vernon Shale

87 ft. Vernon red shale. Some green shale near base. Outcrops at bridge over College Hill creek and continues downstream 955 ft.

	Lockport Dolomite	
63 ft.	Dark gray argillaceous dolomite. Some shale layers. Abundance of dark gray dolomitic shale at base especially. Contact unconformable.	
Upper Clinton		
	Herkimer Sandstone	
5 ft. 6 in.	Sandstone. Medium gray, calcareous, massive-bedded. Top very irregular. Fossils.	*Crinoid stems* *Leptaena rhomboidalis* *Schuchertella subplana*
2 ft. 6 in.	Red, arkosic, cross-bedded sandstone. No fossils.	
2 ft. 6 in.	Covered.	
2 ft.	Medium gray, very sandy limestone with medium gray calcareous shales. Fossils rare.	*Lingula perovata* *Dalmanella elegantula* *Leptaena rhomboidalis*
3 ft.	Covered.	
2 ft. 6 in.	Red to brown sandstone. No fossils.	
3 ft.	Covered.	
8 ft. 6 in.	Dark gray to medium gray, calcareous, silty, hard shale and thin red sandstone. Wave marks and ripple marks. No fossils.	
1 ft. 6 in.	Medium gray argillaceous limestone.	*Schuchertella subplana* *Stropheodonta profunda*
17 ft. 9 in.	Covered.	
4 ft. 3 in.	Light gray, crystalline, sandy, silty, limestone. Hematitic band near center. Fossiliferous.	*Cladopora seriata* *Fistulipora crustula* *Mesotrypa nummiformis* *Clathropora frondosa* *Rhinopora verrucosa* *Lingula lamellata* *Schuchertella subplana* *S. tenuis* *Atrypa reticularis* *Whitfieldella nitida* *Pentamerus ovalis* *Dawsonoceras annulatum* *Dalmanites limulurus*
16 ft. 8 in.	Covered	
3 ft. 6 in.	Dark gray, calcareous, hard shale. Thin sandy limestone layers. Thin stringers of hematite. Poorly exposed. Contact	*Dictyonema retiforme* *Fenestella elegans* *Eridotrypa solida* *Lioclema asperum* *Acanthoclema asperum*

	gradational and located about 3700 ft. east of road.	*Clathropora frondosa* *Stictotrypa punctipora* *Lingula lamellata* *Dalmanella elegantula* *Homalonotus delphinocephalus* *Cheirurus niagarensis* *Dalmanites limulurus*

Kirkland Iron Ore

4 ft. 7 in.	Red, hematitic limestone. Some layers sandy, some argillaceous. Hematite concentration greater near the center. Some siderite. Fossils only partly replaced.	*Cladopora seriata* *Eridotrypa solida* *Fenestella elegans* *Acanthoclema asperum* *Schuchertella subplana*

Dawes Quarry Creek — Section 33

Town of Kirkland. County of Oneida. Located east of the main part of the village of Clinton and on a creek which is crossed by a north-south road which forms with the Clinton-Willowvale road the second three corners east of Clinton village. Rock outcrops on both sides of the bridge over that stream.

Top

Upper Clinton

Herkimer Sandstone

5 ft. 6 in.	Light gray, thin-bedded, calcareous sandstone. Wave and ripple marks.	*Crinoid stems*
2 ft.	Green sandy shale. Slightly calcareous. Unfossiliferous.	
3 ft. 4 in.	Light gray, thin-bedded, calcareous sandstone. Shale partings abundant. Bedding irregular.	*Buthotrephis gracilis* *B. palmata* *Strophomena orthididea* *Crinoid stems*
2 ft. 6 in.	Green, silty shale.	*Buthotrephis gracilis* *B. palmata*
6 ft.	Light to medium gray sandstone. Mostly thin-bedded. Shale partings abundant.	*Dalmanella elegantula* *Rafinesquina obscura* *Schuchertella subplana* *Rhynchonella plicatella* *Rhynchotreta cuneata*
2 ft.	Gray sandstone and green shale interbedded. Wave and ripple marks and mud cracks common.	*Buthotrephis gracilis* *B. palmata* *B. ramosa* *Rusophycus biloba* *R. subangulatum*
1 ft. 6 in.	Light gray sandstone with shale partings. Quite fossiliferous.	*Dalmanella elegantula* *Leptaena rhomboidalis* *Rafinesquina obscura*

		Schuchertella subplana *Stropheodonta profunda* *Strophomena orthididea* *Pentamerus ovalis* *Rhynchotreta cuneata* *Pterinea emacerata* *Modiolopsis ovata* *M. subcarinata*
3 ft.	Green, silty shale with thin sandstone layers. Mud cracks common. Unfossiliferous.	
13 ft. 9 in.	Light gray sandstone becoming calcareous toward the base. Some sandy limestones in basal portion. Shale partings common. Fossiliferous. Hematitic stringers common near the base. Contact gradational and located 750 ft. downstream from road.	*Cladopora seriata* *Fenestella elegans* *Dalmanella elegantula* *Leptaena rhomboidalis* *Rafinesquina obscura* *Schuchertella subplana* *Stropheodonta profunda* *Strophomena orthididea* *Pentamerus ovalis* *Rhynchotreta cuneata* *Cuneamya alveata* *Ctenodonta elliptica* *Leptodesma rhomboideum* *Pterinea emacerata* *Modiolopsis ovata* *M. subcarinata* *Strophostylus cancellatus* *Conularia niagarensis* *Dawsonoceras annulatum* *Calymene niagarensis* *Homalonotus delphinocephalus* *Dalmanites limulurus* *Paraechmina postica* *P. spinosa* *Dizygopleura proutyi* *Beyrichia veronica*
	Kirkland Iron Ore	
5 ft. 2 in.	Red, hematitic limestone. Hematitic content variable. Contact abrupt.	*Cladopora seriata* *Fistulipora crustula* *Eridotrypa solida* *Fenestella elegans* *Acanthoclema asperum* *Clathropora frondosa* *Schuchertella subplana*
	Dawes Sandstone	
8 ft.	Light gray, massive, cross-bedded sandstone. Unfossiliferous. Upper part stained red due to ground water. Contact unconformable.	

No further outcrops in the bed of the stream. About 1500 feet below the road on the east side of the stream are the old open cuts of the Franklin iron ore mine. The ore was worked by the open cut

method until the overburden became too great, then underground methods were employed.

Upper Clinton

Willowvale Shale

18 ft. 4 in.	Green, calcareous shale with thin limestone layers. Shale poorly exposed due to weathering.	*Palaeocyclus rotuloides* *Dictyonema gracilis* *D. retiforme* *Retiolites venosus* *Monograptus clintonensis* *Lingula lamellata* *Pholidops squamiformis* *Dalmanella elegantula* *Leptaena rhomboidalis* *Sowerbyella transversalis* *Schuchertella subplana* *Chonetes cornutus* *Scenidium pyramidale* *Camarotoechia acinus* *Atrypa reticularis* *Cyrtia meta* *Spirifer radiatus* *Coelospira sulcata* *Ctenodonta mactriformis* *Leptodesma rhomboidea* *Pterinea emacerata* *Cyclonema varicosum* *Orthoceras bassleri* *Dawsonoceras annulatum* *Calymene clintoni* *C. niagarensis* *Dalmanites limulurus* *Mastigobolbina punctata* *M. trilobata* *M. typus* *Beyrichia* aff. *lakemontensis* *Dibolbina* n. sp.

Westmoreland Iron Ore

3 ft.	Red, oolitic iron ore with a shale parting near the center. Poorly exposed. Much talus had to be removed in making the estimate of thickness. All the fossils listed come from shale parting.	*Palaeocyclus rotuloides* *Lingula lamellata* *Leptaena rhomboidalis* *Sowerbyella transversalis* *Chonetes cornutus* *Atrypina disparilis* *Spirifer radiatus* *Coelospira sulcata* *Calymene clintoni* *C. niagarensis* *Dalmanites limulurus lunatus*

WILLOWVALE SECTION 34

Town of New Hartford. County of Oneida. A very good section is exposed by the creek which flows east into Sauquoit creek at Willowvale. The rock is found in the stream bed and in cliffs along the stream. There are three artificial lakes, which cover some rock, but by studying both the stream bed and cliffs a nearly complete section can be obtained. The area of outcrop was once used as a picnic ground which was known in the past as Roger's Glen.

Top

Upper Clinton

Herkimer Sandstone

41 ft. 6 in. Light gray, slightly calcareous sandstone. Lowest layer more calcareous. Some sandy limestone. Mostly thin-bedded stringers of hematite in basal part. This part of the section is found above the natural falls. A cliff above the falls about 2500 ft. west of main street in Willowvale, exposes much of section. Contact **gradational.**

Buthotrephis ramosa
Palaeophycus striatum
Rusophycus biloba
R. subangulatum
Cladopora seriata
Rafinesquina obscura
Schuchertella subplana
Stropheodonta profunda
Pentamerus ovalis
Rhynchonella plicatella
Rhynchotreta cuneata
Mytilarca mytiliformis
Modiolopsis ovata
M. subcarinatus
Orthoceras clavatum
Dawsonoceras annulatum
Homalonotus delphinocephalus
Dalmanites limulurus
Dizygopleura proutyi

Kirkland Iron Ore

4 ft. 2 in. Red, hematitic limestone. Some pyrite and siderite. Fossils abundant. Fossils not dwarf. This limestone forms cap rock of the falls. Contact **unconformable.**

Cladopora seriata
Eridotrypa solida
Fenestella elegans
Acanthoclema asperum
Stictotrypa punctipora
Leptaena rhomboidalis
Rafinesquina obscura
Schuchertella subplana
Stropheodonta profunda
Atrypa reticularis
Homalonotus delphinocephalus
Dalmanites limulurus

Willowvale Shale

2 ft. 10 in. Bluish gray calcareous shale. Shale crumbles rather than breaks parallel to any bedding. Fossils abundant but poorly preserved. Many broken. May represent a reworking of lower shale. Contact gradational.

Mesotrypa nummiformis
Dalmanella elegantula
Leptaena rhomboidalis
Sowerbyella transversalis
Schuchertella subplana
Chonetes cornutus
Camarotoechia neglecta
Atrypa reticularis
Spirifer radiatus
Nucleospira pisiformis
Whitfieldella intermedia
Coelospira sulcata
Ctenodonta machaeriformis
Pyrenomoeus cuneatus
Cyclonema varicosum
Strophostylus cancellatus
Dawsonoceras annulatum
Calymene clintoni
Dalmanites limulurus
Mastigobolbina punctata
M. trilobata
M. typus
Plethobolbina typicalis

18 ft. 3 in.	Greenish gray shale with thin limestone layers near the base. Thin-bedded and splits parallel to the bedding planes. The lowest layer outcrops 20 ft. downstream from the dam which forms the second lake about 2025 ft. west of the main street of Willowvale.	*Palaeocyclus rotuloides* *Chaetetes lycoperdon* *Dictyonema gracilis* *D. retiforme* *Retiolites geinitzianus venosus* *Monograptus clintonensis* *Ceramopora imbricata* *Eridotrypa striata* *Fenestella elegans* *Semicoscinium tenuiceps* *Acanthoclema asperum* *Rhinopora verrucosa* *Dalmanella elegantula* *Bilobites biloba* *Leptaena rhomboidalis* *Sowerbyella transversalis* *Schuchertella elegans* *S. subplana* *S. tenuis* *Strophonella patenta* *Chonetes cornutus* *Camarotoechia neglecta* *Rhynchonella bidens* *Atrypa nodostriata* *A. reticularis* *Spirifer radiatus* *Nucleospira pisiformis* *Coelospira sulcata* *Cuneamya alveata* *Ctenodonta machaeriformis* *Pyrenomoeus cuneatus* *Leptodesma rhomboidea* *Pterinea emacerata* *Hormotoma subulata* *Cyclonema varicasum* *Orthoceras annulatum* *Dawsonoceras annulatum* *Calymene clintoni* *Dalmanites limulurus* *Mastigobolbina punctata* *M. trilobata* *M. typus* *Plethobolbina typicalis* *Beyrichia* aff. *lakemontensis*
6 ft.	Covered. The topography is such that it can not be uncovered without an enormous amount of work. Pieces of oolitic ore were found in the stream and along the steep banks, but its exact location could not be determined. This area is found at the dam which forms the second lake.	

Middle Clinton

Sauquoit Shale

19 ft. 9 in.	Bluish green, fissile, sandy shale. Thin sandstone layers. Poorly exposed.	
8 ft. 6 in.	Bluish green, fissile, sandy shale. Thin sandstones abundant. Well-exposed. Very fossiliferous. Exposed in	*Chaetetes lycoperdon* *Leptaena rhomboidalis* *Chonetes cornutus* *Coelospira hemispherica* *Pterinea emacerata*

	stream bed between first and second lake.	*Diaphorostoma hemisphericum* *Conularia niagarensis* *C. longa* *Zygobolbina conradi* *Mastigobolbina clarkei* *M. lata* *M. lata* var. *nana* *M. vanuxemi*
20 ft. 4 in.	Bluish green, fissile, sandy shale. Poorly exposed. Last outcrop about 100 ft. below first dam.	
8 ft. 9 in.	Greenish gray, very sandy shale. Sandy limestone layers near center. Irregular conglomeratic masses common. Wave and ripple marks and mud cracks. Fossils rare. Some excellent ostracods.	*Zygobolbina conradi* *Mastigobolbina lata* *M. lata* var. *nana*
9 ft.	Greenish gray, slightly calcareous shale. Mud cracks common. Very fossiliferous.	*Leptaena rhomboidalis* *Chonetes cornutus* *Atrypa reticularis* *Atrypina disparilis* *Leptodesma rhomboideum* *Amphicoelia orbiculoides* *Cyclonema varicosum* *Bucanella trilobata* *Calymene clintoni* *C. niagarensis* *Dalmanites limulurus lunatus* *Zygobolbina conradi* *Mastigobolbina lata* *M. lata* var. *nana* *M. vanuxemi*
4 ft. 6 in.	Green and greenish gray, very sandy shale with thin-bedded green, argillaceous sandstone. Conglomeratic masses common. Fossils rare and poorly preserved.	
7 ft. 9 in.	Green, silty, slightly calcareous, sandy shale. Conglomeratic masses present. Poorly exposed.	
1 ft. 3 in.	Light to medium gray, quartz conglomerate. Some phosphatic material.	
12 ft. 7 in.	Bluish gray, slightly calcareous, slightly sandy shale. Thin-bedded. Some mud cracks and wave and ripple marks. Very fossiliferous.	*Leptaena rhomboidalis* *Chonetes cornutus* *Coelospira hemispherica* *Ctenodonta machaeriformis* *Cyrtodonta alata* *Leptodesma rhomboideum* *Pterinea emacerata*

Amphicoelia orbiculoides
Bucanella trilobata
Cyclonema varicosum
Calymene clintoni
Dalmanites limulurus lunatus
Zygobolbina conradi
Mastigobolbina lata
M. lata var. ***nana***
M. vanuxemi

1 ft. 6 in. Light to medium gray conglomerate. May be beginning of Oneida. Conglomerate located 350 ft. upstream from main street of Willowvale.

DESCRIPTION OF DIAMOND DRILL CORES

The eight state-owned diamond drill cores were loaned to the writer through the courtesy of C. A. Hartnagel. They were a great aid not only in determining the lithology and thickness of the various Clinton formations, but also in correlating and giving the stratigraphic position of many of the small isolated outcrops many of which otherwise would have been useless.

The lithology and fossil content of the cores are described on the following pages. The cores are designated by letters A to H. Their location is shown on the accompanying map (figure 1, page 7).

Wallington Drill Core — Section A

Town of Sodus. County of Wayne. The test hole is located on the west bank of Salmon creek 90 feet north of United States Highway 104.

Top

Pleistocene and Recent

2 ft. 6 in. Soil.

Upper Clinton

Rochester Shale

67 ft. 6 in. Brownish gray, calcareous shale with many argillaceous limestone layers. The lower part is a dark gray shale with light gray limestone members. Very fossiliferous. Contact sharp.

Irondequoit Limestone

8 ft. 2 in. Crystalline, light gray limestone layers with shale layers. Crinoid stems abundant. *Whitfieldella intermedia* common. Contact gradational.

10 ft. 1 in. Bluish gray calcareous shale with limestone members. *Mastigobolbina trilobata.* Contact gradational.

Williamson Shale

18 ft. 6 in. Green fissile shale, the basal part of which contains black layers. Thin limestone layers present. Some limestone composed of *Sowerbyella transversalis*. *Monograptus clintonensis* plentiful.

At base of Williamson a few inches of column are missing. May represent the unconformity noted on Second creek.

Lower Clinton

Wolcott Limestone

2 ft. 10 in. Bluish gray shale. Thin-bedded. No *Pentamerus*. Probably Wolcott Furnace iron ore horizon.

14 ft. 6 in. Bluish gray limestone. Some layers crystalline. Thin shale layers common. *Pentamerus oblongus* occurs at four horizons. First upper 9 in., second 17 in. layer 34 in. from the top, third 4 ft. with *Pentamerus* throughout 68 in. from the top, fourth occurs at the very base of the limestone.

Upper Sodus Shale

2 ft. 10 in. Transition limestone and shale. Limestone predominates at the top, shale at the base.

34 ft. 9 in. Green, calcareous shale with limestone layers. These limestones commonly called pearly layers. Composed almost entirely of *Coelospira hemispherica*. *Zygobolba decora* is common. In drawing the line between this shale and the one below a careful search for ostracods was made. It was found that the shale above the 6-in. pearly layer contained *Zygobolba decora* and that below had *Zygolbolba excavata* and *Zygobolba prolixa*. This 6-in. pearly layer appears to occur at the same horizon that the 7-in. pearly layer occupies on Salmon creek. Contact sharp.

Lower Sodus Shale

16 ft. 2 in. Green and dark gray or purple shale. Upper part predominately green. Lower part predominately dark gray. Limestone layers composed of *Coelospira hemispherica* common. The most common ostracods in the upper part *Zygobolba excavata* and *Zygobolba prolixa*. In the basal part *Zygobolba curta* predominates. At the base is a one-inch band of hematitic material. Contact sharp.

Reynales Limestone

12 ft. 6 in. Dark to light gray limestone. The upper part thin-bedded. The upper and middle portions contain an abundance of chert. *Pentamerus oblongus* characteristic. Contact gradational.

Furnaceville Iron Ore

2 ft. 6 in. Limestone with hematite. The hematitic content is not high at any one point, but the lower 11 in. contains the most. Contact sharp.

Thorold Sandstone

5 ft. Green-gray, shaly, calcareous sandstone. The upper part has black phosphatic nodules. Some of the sandstone layers have clay pellets imbedded in them.

Albion Group

Grimsby Sandstone

Red sandstone.

Wolcott Drill Core — Section B

Town of Wolcott. County of Wayne. Test hole is located north of the falls at Wolcott and on the east bank of Wolcott creek.

Top

Pleistocene and Recent

5 ft. 6 in. Soil.

Upper Clinton

Rochester Shale

39 ft. Brown and gray calcareous shale with many limestone layers. Very fossiliferous. Contact sharp.

Irondequoit Limestone

6 ft. 2 in. Gray crystalline limestone. A few layers crinoidal.

28 ft. 6 in. Bluish gray, calcareous shale with limestone members. Shale crumbles rather than cleaves. Contact gradational.

Williamson Shale

22 ft. 9 in. Green fissile shale with some dark colored layers near the base. Few limestone layers most of which are less than 2 in. thick. *Sowerbyella transversalis* abundant in limestones. *Atrypa reticularis* and *Monograptus clintonensis* abundant in shales.

Unconformity pronounced.

Lower Clinton

Wolcott Furnace Iron Ore

1 ft. Hematitic limestone. Concentration greatest in lower 6 in. Contact gradational.

Wolcott Limestone

19 ft. 6 in. Bluish gray limestone. Many bluish gray calcareous shale layers. *Pentamerus oblongus* at three horizons. Contact gradational.

Upper Sodus Shale

42 ft. 6 in Green, calcareous shale. Some layers near top bluish gray in color. Pearly layers common and reach a thickness of 5 in. Also some crystalline limestones. Shales abound in *Coelospira hemispherica, Strophcodonta corrugata, Zygobolba decora* and *Zygobolba robusta*. Contact questionable.

Lower Sodus Shale

19 ft. 6 in. Greenish gray shale with dark gray or purple shale abundant at base. Crystalline limestone layers present. None of the limestones are pearly. Shale contains *Coelospira hemispherica, Tentaculites minutus, Zygobolba curta, Zygobolba prolixa* and *Zygobolba excavata*. At the base is a 2 in. layer of hematitic limestone. Ore marks an abrupt change in lithology. Contact sharp.

Reynales Limestone

12 ft. 2 in. Alternating gray limestone and dark gray shale. The upper 20 in. contains fossils, *Pentamerus oblongus*. The middle portion cherty. The lower 2 ft. has tiny stringers of hematite. Contact gradational.

Furnaceville Iron Ore

2 ft. 9 in. Hematitic limestone interbedded with shale. Hematite is concentrated at top and bottom, the two layers being separated by a shaly limestone. Contact sharp.

Thorold Sandstone

2 ft. 1 in. Shaly, calcareous sandstone. The middle portion a green, platy shale. The upper 8 in. a green, sandy shale with fine-grained nodules of phosphatic material.

RED CREEK DRILL CORE — SECTION C

Town of Sterling. County of Cayuga. Test hole is located just to the north of the improved Red Creek-Sterling Station road, two miles northeast of Red Creek and three miles southwest of Sterling Station. The well was drilled on the bank of one of the minor branches of Blind Sodus creek.

Top

Pleistocene and Recent

9 ft. Soil and glacial drift.

Upper Clinton

Rochester Shale

14 ft. Brown and gray calcareous shale interbedded. Some argillaceous limestone.

Irondequoit Limestone

6 ft. Gray, argillaceous limestone. The basal part a pure crystalline limestone. The central portion a calcareous shale. The upper 15 in. is very fossiliferous, *Whitfieldella cylindrica*, *Mastigobolbina punctata* found near center. Contact gradational.

29 ft. 4 in. Gray, calcareous shale with a few argillaceous limestone members. Some layers fissile. Fossiliferous but none identified.

Williamson Shale

31 ft. 6 in. Green and gray fissile shale. A few black layers in the lower and central portions. Some thin limestones composed entirely of *Sowerbyella transversalis*, *Monograptus clintonensis* and *Dibolbina* n. sp. common in shale layers.

Unconformity clearly marked.

Lower Clinton

Wolcott Furnace Iron Ore

1 ft. 4 in. Bluish gray, calcareous shale. Oolites of hematite. Phosphatic nodules. One inch of oolitic iron ore at base. Contact gradational.

Wolcott Limestone

16 ft. 10 in. Light gray limestone with some bluish gray, calcareous shale layers. Much of limestone argillaceous. *Pentamerus oblongus* at two horizons. *Pentamerus* only in crystalline limestone. Contact gradational.

Upper Sodus Shale

44 ft. 1 in. Greenish gray, calcareous shale with bluish gray shale layers in upper part. Some dark gray shales near base. Pearly limestone layers especially in upper part. The shales contain *Coelospira hemispherica, Zygobolba decora* and *Zygobolba robusta.* Contact not easily distinguished.

Lower Sodus Shale

21 ft. 6 in. Purplish gray shale with some greenish gray shale. Many thin limestone layers. One is 13 in. thick, but most are less than 4 in. thick. Limestones in upper part pearly. Limestones in lower part crystalline with brownish color. Four-inch hematitic layer at the base. *Zygobolba excavata* present.

Reynales Limestone

10 ft. 10 in. Dark gray or purple shale and dark gray argillaceous limestones. The upper 2 in. is fossiliferous. In the shale near center *Zygobolba curta* was identified.

Furnaceville Iron Ore

2 ft. 6 in. Red hematitic fossiliferous limestone. Two inches of shale near center.

Thorold Sandstone

3 ft. 6 in. Greenish gray, calcareous shaly sandstone. The upper 8 in. very shaly.

MARTVILLE DRILL CORE — SECTION D

Town of Sterling. County of Cayuga. The test hole is located on the west bank of Little Sodus creek and 15 rods north of the main highway to Hannibal.

Top

Pleistocene and Recent

18 ft. Glacial till.

Lower Clinton

Upper Sodus Shale

35 ft. Greenish gray shale with some dark gray shale layers becoming more abundant toward the base. Pearly limestone especially abundant in the lower part of the upper half. Some crystalline unfossiliferous limestones. *Coclospira hemispherica* and *Tentaculites minutus* in shale. *Zygobolba decora* also present. No definite break at base. Contact drawn where dark gray dominates. Ostracods aid in determining contact.

Lower Sodus Shale

30 ft. 6 in. Dark gray or purple shale with limestone lenses. Thin limestones common. Limestones crystalline, some with brownish color. The shales contain *Phaenopora ensiformis, Coelospira hemispherica, Zygobolba excavata* and *Zygobolba curta.* Contact sharp.

Bear Creek Shale

10 ft. 1 in. Dark gray or purplish shales with some interbedded argillaceous limestones. Shale layers contain pelecypods and *Coelospira hemispherica.* The top is marked by 1 in. of hematitic material Stringers of hematite in basal 2 ft. Contact gradational.

Furnaceville Iron Ore

3 in. Red hematitic argillaceous limestone. Black phosphatic nodules common at base.

Thorold Sandstone

4 ft. 2 in. Gray, argillaceous, calcareous sandstone. Upper part interbedded with green shale.

South Granby Drill Core — Section E

Town of Granby. County of Oswego. The test hole is located one and a half miles north of Little Utica and one mile southwest of South Granby on the west side of the north-south road and just north of the little stream which crosses the road at that point.

Top

Pleistocene and Recent

22 ft. Soil, sand and gravel.

Upper Clinton

Rochester Shale

16 ft. 9 in. Brownish gray, calcareous shale. Very fossiliferous. Contact sharp.

Irondequoit Limestone

8 ft. Dark gray, argillaceous limestone. Upper part very fossiliferous. Crinoid stems. *Whitfieldella cylindrica.* Contact gradational.

3 ft. 2 in. Dark gray, tough, calcareous shale. Sparingly fossiliferous. *Mastigobolbina trilobata.* Contact sharp.

1 ft. 9 in. Crystalline crinoidal limestone. Contact gradational.

9 ft. 1 in. Dark gray argillaceous, some pyritic limestone. Shale partings abundant. Fossiliferous. Contact gradational.

Williamson Shale

18 ft. 6 in. Dark green to gray massive calcareous shale with some thin limestone layers. Toward base limestone filled with *Sowerbyella transversalis. Monograptus clintonensis* in shales. Contact sharp.

7 ft. 3 in. Blue to brown calcareous shale. Thick-bedded. *Mastigobolbina punctata.*

15 ft. 3 in. Dark greenish gray fissile shale. A very few thin limestones. *Monograptus clintonensis, Sowerbyella transversalis.* Basal few inches very pyritic with a thin stringer of hematitic limestone. Contact sharp.

Middle Clinton

Sauquoit Shale

16 ft. 4 in. Dark brownish gray to brown shale. Some thin-bedded, and fissile. Some near center calcareous. Thin limestone at top. Contact gradational.

16 ft. 8 in. Dark gray fissile shale. Very thin layers of limestone or calcareous material at base. Contact sharp.

Lower Clinton

Wolcott Limestone

11 in. Light gray limestone, largely composed of crinoid stems. Hematite abundant in the upper part where it replaces fossils.

2 ft. 7 in. Bluish gray calcareous shale. Lacy bryozoans abundant.

6 in. Argillaceous oolitic hematitic iron ore.

8 in. Bluish gray calcareous shale with thin limestone layers.

10 in. Light gray fossiliferous limestone. An abundance of hematite especially near center.

4 ft. 6 in. Light gray, fossiliferous limestone with shale partings. *Pentamerus oblongus.*

6 ft. 2 in. Light gray, dense crystalline limestone with an abundance of shale partings. Contact gradational.

Upper Sodus Shale

2 ft. 4 in. Light bluish gray shale with dense limestones.

39 ft. 8 in. Greenish gray calcareous shale. Some light bluish gray at top. Dark gray shale abundant at the base. Thin pearly limestone layers especially abundant in the upper half. Some brownish crystalline limestone near base. *Coelospira hemispherica* abundant. *Tentaculites minutus, Zygobolba decora, Zygobolba robusta* and *Mastigobolbina incipiens.* Contact indefinite. Drawn on basis of ostracods and change in lithology.

Lower Sodus Shale

20 ft. Dark gray, slightly calcareous, fossiliferous shale with a few limestone layers, none of which are pearly. Pelecypods noted in basal portion. *Coelospira hemispherica* and *Zygobolba excavata* also identified. Contact sharp.

Bear Creek Shale

9 ft. 10 in. Dark gray, slightly calcareous shale with argillaceous limestone. Basal portion slightly sandy. Contact gradational.

Furnaceville Iron Ore

8 in. Red argillaceous hematitic limestone.

Thorold Sandstone

4 ft. 3 in. Green argillaceous, calcareous sandstone with shale layers. Phosphatic nodules abundant.

BREWERTON DRILL CORE SECTION F

Town of Cicero. County of Onondaga. The test hole is located on the south bank of Oneida river about 230 feet west of the bridge on United States Highway 11.

Top

Pleistocene and Recent

14 ft. Clay.

Upper Clinton

Williamson Shale

5 ft. 4 in. Dark green, fissile shale with thin limestones composed of *Sowerbyella transversalis*. 4 in. layer with glauconite and phosphatic nodules at base. Contact sharp.

Middle Clinton

Sauquoit Shale

14 ft. 4 in. Dark bluish green fissile silty shale.

16 ft. 6 in. Dark green thinly laminated shale. Some slightly calcareous. Thin crystalline unfossiliferous limestones common.

6 ft. 2 in. Dark bluish gray calcareous sandy and silty shale with some thin limestones and thin partings of sandstone. Contact sharp.

Lower Clinton

Wolcott Furnace Iron Ore

1 ft. 11 in. Red hematitic limestone stringers in a bluish gray, sandy and calcareous shale. Upper 2 in. show greatest concentration of hematite. Lacy bryozoans abundant. Contact gradational.

Wolcott Limestone

14 ft. 3 in. Light gray to bluish gray, very argillaceous limestone with a few crystalline layers. Brownish and bluish gray calcareous shale abundant. Limestone layers unfossiliferous. Many limestones show trace of hematite as thin stringers. Shale layers abound in *Fenestella tenuis, Semicoscinium tenuiceps*. One ostracod, *Mastigobolbina incipiens*. Contact gradational.

Upper Sodus Shale

7 ft. Bluish gray and greenish gray calcareous shales interbedded with thin limestones. Shales show an abundance of *Coelospira hemispherica, Tentaculites minutus, Zygobolba decora, Zygobolba robusta, Mastigobolbina incipiens* and *Mastigobolbina retifera*. Contact gradational.

35 ft. 3 in. Greenish gray, calcareous shale with thin pearly limestone layers. Some dark gray or purple shale in the basal portion. Shales very fossiliferous with *Coelospira hemispherica, Stropheodonta corrugata* and *Zygobolba decora* especially prominent. Contact indefinite.

Lower Sodus Shale

18 ft. 3 in. Dark gray shale with a few greenish gray layers. Thin crystalline limestones, mostly brownish in color, are common. Shale fossiliferous. *Coelospira hemispherica, Pterinea emacerata, Tentaculites minutus, Zygobolba prolixa* and *Zygobolba curta*. Contact sharp but conformable.

Bear Creek Shale

4 ft. 8 in. Dark gray shale with dark gray argillaceous limestones. Top marked by a thin oolitic hematitic limestone. Stringers of hematite found throughout upper 1 ft. 6 in.

8 in. Dark gray argillaceous calcareous sandstone with scattered oolites of hematite. Contact gradational.

Furnaceville Iron Ore

1 ft. 4 in. Red oolitic iron ore. High concentration of hematite.

Oneida Conglomerate

5 ft. 4 in. Light gray argillaceous sandstone grading downward into a quartz conglomerate. A very few green sandy and silty shale partings.

Lakeport Drill Core — Section G

Town of Sullivan. County of Madison. The test hole is located one and a half miles northeast of Lakeport and one-quarter of a mile south of Oneida lake.

Pleistocene and Recent

7 ft. Soil and glacial drift.

Lockport

10 ft. 7 in. Dark gray dolomite. Medium bedded.

11 in. Dark gray dolomitic shale.

2 ft. 6 in. Dark gray dolomitic limestone. Contact sharp.

Upper Clinton

Rochester Shale

10 ft. 3 in. Dark brownish gray, calcareous, slightly sandy, tough, fossiliferous shale. Contact sharp.

23 ft. 7 in. Alternating thin-bedded shales with lesser amounts of argillaceous limestone layers. A few crystalline limestones.

11 ft. 7 in. Light gray limestone with some argillaceous limestone layers and an abundance of dark gray calcareous shales. Crystalline limestones usually show trace of hematite. Basal 11 in. contains an abundance of hematite which replaces fossils.

8 ft. 8 in. Dark brownish gray, calcareous shale with an abundance of argillaceous limestones. Shale very fossiliferous.

20 ft. 8 in. Dark gray, sandy, calcareous shale with an abundance of thin calcareous sandstones.

18 ft. 1 in. Dark gray, calcareous shale with argillaceous sandy limestones abundant. A few thin argillaceous sandstones.

15 ft. 2 in. Dark bluish gray calcareous shale with argillaceous limestone layers. Shale layers are very fossiliferous. Contact sharp.

Irondequoit–Williamson

5 ft. 10 in. Dark gray, calcareous limestone with interbedded crystalline limestone layers. Some shale partings. Limestone layers crinoidal. Upper 18 in. hematitic.

11 ft. 4 in. Bluish gray, calcareous shale. Massive bedded with a few very thin crystalline limestone layers. Fossiliferous.

24 ft. 2 in. Thin-bedded dark green, fissile shale with an abundance of thin limestones bearing *Sowerbyella transversalis*. Graptolites very common.

27 ft. 9 in. Dark greenish gray thin-bedded, slightly sandy shale. Basal 3 ft. has a brownish gray color.

11 ft. 5 in. Dark greenish gray fissile shale. *Monograptus clintonensis* abundant. Base marked by a thin sandstone 2 in. to 3 in. thick. Contact sharp.

Middle Clinton

Sauquoit Shale

19 ft. 5 in. Dark green, fissile, slightly sandy and silty shale. *Zygobolbina conradi.*

8 ft. 9 in. Dark gray, slightly sandy shale.

30 ft. 4 in. Dark gray shale. Thin-bedded. Some slightly calcareous. Some slightly sandy. An abundance of thin sandy limestone layers. *Mastigobolbina lata.*

17 ft. Dark bluish gray shale with some thin sandstone layers. Contact sharp.

Lower Clinton

Wolcott Furnace Iron Ore

2 ft. Bluish gray shale with scattered oolites of hematite. Upper surface covered with hematite. Very fossiliferous. Lacy bryozoans.

Wolcott Limestone

8 ft. 8 in. Bluish gray argillaceous limestone with an abundance of bluish gray calcareous shale. A few thin crystalline limestone layers. Thin stringers of hematite common throughout the whole thickness.

1 ft. 10 in. Red hematitic limestone. Upper 8 in. shows high concentration of hematite. Thin shale layers common. Basal 3 in. is an argillaceous sandstone containing considerable hematite. Contact sharp.

Upper Sodus Shale

32 ft. Greenish gray, calcareous shale. Upper portion contains some bluish gray layers. Thin crystalline limestones common, a few of which are pearly. Fossiliferous. *Coelospira hemispherica, Strophеodonta corrugata* and *Zygobolba decora.* Contact sharp and marked by a thin hematitic layer.

Lower Sodus Shale

12 ft. 1 in. Dark gray shale with thin crystalline limestone layers, most of which are brownish in color. *Coelospira hemispherica, Tentaculites minutus* and *Zygobolba excavata.* Contact sharp.

Bear Creek Shale

1 ft. 4 in. Argillaceous limestone. Stringers of hematite throughout. A thin layer of hematite at the top. A layer 7 in. thick near center shows a high concentration of hematite. Branching bryozoans common in hematitic portion. Contact appears sharp.

Furnaceville Iron Ore

4 in. Red, hematitic, fossiliferous iron ore. Fragments of *Coelospira* replaced by hematite. Character of ore and sharpness of contact are bases for separating this lower 4 in. from the Bear Creek shale. Contact sharp.

Oneida Conglomerate

2 ft. 7 in. Gray sandstone with green silty shale layers. Two-inch quartz conglomerate in middle of formation.

Verona Station Drill Core — Section H

Town of Verona. County of Oneida. Test hole is located about 300 feet west of the railroad station at Verona Station and on the south side of the highway. It is situated on the bank of a small tributary of Stony creek.

Top

Pleistocene and Recent

18 ft. Sand and Clay.

Middle Clinton

Sauquoit Shale

19 ft. 2 in. Bluish gray sandy shale with thin sandy limestones. Contact sharp.

Lower Clinton

Wolcott Furnace Iron Ore

1 ft. Red hematitic limestone. Fossils abundant. Contact sharp.

Upper Sodus Shale

36 ft. 2 in. Greenish gray shale with thin limestones in the upper part. Thin sandstones are abundant near the base of the formation. Shales fossiliferous. *Coelospira hemispherica, Strophcodonta corrugata* and *Zygobolba decora.* Contact gradational.

Oneida Conglomerate

10 ft. White sandstones interbedded with green sandy shales. Some conglomeratic layers especially near base.

BIBLIOGRAPHY

Alling, H. L.

1936 Petrology of the Niagara gorge sediments. Proc. Rochester Acad. Sci., 7:189–207.

Bassler, R. S.

1906 The bryozoan fauna of the Rochester shale. U. S. Geol. Surv. Bul. 292. 136p.

1915 Bibliographic index of American ordovician and silurian fossils. U. S. Nat. Mus. Bul. 92, 2v. 1521p.

Chadwick, G. H.

1918 Stratigraphy of the New York Clinton. Geol. Soc. Amer. Bul., 29:327–68.

1935 Thorold sandstone. Amer. Ass'n. Petrol. Geol. Bul., 19:702.

Clarke, J. M.

1903 Classification of the New York series of formations. Univ. State of N. Y. Handbook 19. 26p.

Clarke, J. M. & Schuchert, C.

1899 The nomenclature of the New York series of geological formations. Science, n. s., 10:874–78.

1900 Nomenclature of the New York series of geologic formations. Amer. Geol., 16:17.

Delo, D. M.

1940 Phacopid trilobites of North America. Geol. Soc. of Amer. Special Paper 29. 133p.

Eaton, A.

1829 A geological and agricultural survey of the districts adjoining the Erie canal in New York State. 163p. Albany.

Gillette, Tracy

1940 Geology of the Clyde and Sodus Bay quadrangles. N. Y. State Mus. Bul. 320. 179p.

Goldring, W.

1931 Handbook of paleontology for beginners and amateurs. Pt II: The Formations. N. Y. State Mus, Handbook 10. 488p.

Grabau, A. W.

1901 Geology and paleontology of Niagara Falls and vicinity. N. Y. State Mus. Bul. 45. 284p.

1908 A revised classification of the North American Silurian. Science, n. s., 27:622–23.

1909 Physical and faunal evolution of North America during Ordovician, Siluric, and early Devonic time. Jour. Geol., 17:209–52.

1913 Early paleozoic delta deposits of North America. Geol. Soc. Amer. Bul., 24:399–528.

1921 Textbook of geology. Part 2, Historical Geology. 342p. New York.

Hall, James

1839 Third annual report of the fourth geologic district of the State of New York. N. Y. Geol. Surv. Ann. Rep't, 3:287–339.

1843 Geology of New York. Part IV, Comprising the survey of the fourth geologic district. 883p. Albany.

1852 Description of the organic remains of the lower middle division of the New York system. Pal. N. Y. 2. 362p., 204pl.

Hartnagel, C. A.

1907 Geologic map of the Rochester and Ontario beach quadrangles. N. Y. State Mus. Bul. 114. 35p.

1907 Stratigraphic relations of the Oneida conglomerate. N. Y. State Mus. Bul., 107:27–37.

1912 Classification of the geologic formations of the State of New York. N. Y. State Mus. Handbook 19. 96p.

Kindle, E. M.

1914 What does the Medina sandstone include in the Niagara gorge? Science, n. s., 39:915–18.

Kindle, E. M. & Taylor, F. B.

1913 Niagara folio. U. S. Geol. Folio 190. 25p., maps.

Newberry, J. S.

1884 The deposition of ores. Sch. Mines Quarterly, 5:329–44.

Newland, D. H. & Hartnagel, C. A.

1908 The iron ores of the Clinton formation of New York State. N. Y. State Mus. Bul. 123. 76p.

Sanford, J. T.

1935 The "Clinton" in western New York. Jour. Geol., 43:167–83.

1935 Thorold sandstone. Amer. Ass'n. Petrol. Geol. Bul., 19:1390.

1936 The Clinton in New York. Jour. Geol., 44:797–814.

1939 Sedimentary rocks of the Niagara gorge. Jour. Sed. Petrology, 9, No. 2:77–85.

Sarle, C. J.

1901 Reef structures in the Rochester section. Amer. Geol., 22:281–82.

Schuchert, C.

1910 Paleogeography of North American Siluric or Ontaric period. Geol. Soc. Amer. Bul., 20:427–606.

1914 Medina and cataract formation. Historical Review. Geol. Soc. Amer. Bul., 25:277–320.

Singewald, J. T. Jr.

1911 Iron ores of Maryland. Md. Geol. Surv., 9:121–327.

Smyth, C. H. Jr.

1892 On the Clinton iron ore. Amer. Jour. Sci., 42:487–96.

Swartz, C. K.

1923 Correlation of the Silurian formations of Maryland with those of other areas. Md. Geol. Surv. Silurian:183–230.

1923 Stratigraphic and paleontologic relations of the Silurian strata of Maryland. Md. Geol. Surv. Silurian: 25–52.

Swartz, C. K. & F. M.

1930 Age of the Shawangunk conglomerate of southeastern New York. Am. Jour. Sci., 20:467–74.

1931 Early Silurian formations of southeastern Pennsylvania. Geol. Soc. Amer. Bul., 42:621–62.

Swartz, F. M.

1934 Silurian sections near Mount Union, central Pennsylvania. Geol. Soc. Amer. Bul., 45:81–134.

1935 Relations of the Silurian Rochester and McKenzie formations near Cumberland, Maryland and Lakemont, Pennsylvania. Geol. Soc. Amer. Bul., 46:1165–194.

Ulrich, E. O.

1911 Revision of the Paleozoic system. Geol. Soc. Amer. Bul., 22:281–680.

Ulrich, E. O. & Bassler, R. S.

1923 American Silurian formations. Md. Geol. Surv. Silurian. 233–70.

1923 Paleozoic Ostracods. Their Morphology, Classification and Occurrence. Md. Geol. Surv. Silurian. 271–391.

Vanuxem, Lardner

1839 Third annual report of the geological survey of the third district. N. Y. Geol. Surv. Ann. Rep't, 3:241–85.

1840 Fourth annual report of the geological survey of the third district. N. Y. Geol. Surv. Ann. Rep't, 4:355–83.

1842 Geology of New York, Part III. Comprising the survey of the third geological district. 306p. Albany.

Williams, M. Y.

1919 The Silurian geology and faunas of Ontario Peninsula and Manitoulin Peninsula and adjacent islands. Can. Geol. Surv. Mem. 3, 195p.

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VITA

Tracy Gillette was born September 24, 1905, in the town of Huron, county of Wayne, State of New York. His parents were Enos E. Gillette and Phoebe Tracy Gillette. From the age of six months he lived with his grandparents, Roswell S. Tracy and Jane McLaughlin Tracy.

At the age of seven he entered North Rose Union School. When he was 16 years old and after completing the first year of work in the North Rose High School, he was forced by family circumstances to leave school. For the two succeeding years he worked on his father's muck and fruit farm. When 18 years old he returned to high school and three years later, 1926, was graduated. His grandmother died in 1924.

For the two years directly following high school, he worked at various jobs, during which period his grandfather died.

In the fall of 1928 he entered the University of Rochester and was graduated from that institution with an A.B. degree in 1932. In 1931 he married Ruth Schneeberger of Irondequoit, New York. From 1932 to 1934 he had a graduate teaching assistantship at the University of Rochester and obtained an M.S. degree in 1934. In the fall of 1934 he entered The Johns Hopkins University as a graduate student.